



ROLE OF MULTI-DETECTOR COMPUTED TOMOGRAPHY IN EVALUATION OF PELVIC FRACTURES

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By

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LIST OF CONTENTS

<u>Chapter</u>	<u>Page</u>
ACKNOWLEDGMENT.....	i
LIST OF CONTENTS	ii
LIST OF TABLES	iii
LIST OF FIGURES	iv
LIST OF ABBREVIATIONS.....	vi
I. INTRODUCTION	1
II. AIM OF THE WORK	26
III. PATIENTS	27
IV. METHODS.....	28
V. RESULTS	29
VI. DISCUSSION.....	42
VII. SUMMARY	46
VIII. CONCLUSIONS	47
IX. REFERENCES.....	48
 PROTOCOL	
 ARABIC SUMMARY	

LIST OF TABLES

Table		Page
1	Distribution of patients according to age and sex (n=30)	29
2	Distribution of patients according to cause of trauma (n=30).....	29
3	Distribution of all patients according to final diagnosis by CT (n=30).....	30
4	Distribution of patients according to side of fracture (n=30)	30
5	Distribution of patients with suspected and missed fracture in plain radiography and diagnosed by MDCT (n=30)	30
6	Distribution of patients according to young-burgess classification (n=30)	31
7	Distribution of the patients according to tile classification (n=30)	32
8	Distribution of the patients according to comminution existence (n=30)	32

LIST OF FIGURES

Figure		Page
1	Anterior view of the pelvic atlas	2
2	Lateral view and medial aspect of the hip bone	2
3	Normal acetabular anatomy.....	3
4	Anterior and posterior views of pelvic ligaments.....	4
5	Anterior view of the pelvis (male and female).....	5
6	Anteroposterior radiograph of the male pelvis	6
7	(a) Embedded in clear acrylic and then sliced, Axial CT throw (b) the sacroiliac joints. (c) Cephalad to the dome of the acetabulum, (d) through the dome of the acetabulum	7
8	Axial CT throw (d) the anterior column the posterior column. And the medial wall of the acetabulum. (e) Abone the dome. (f) A slice through the central portion of the acetabulum. (g) The pelvis beyond the acetabulum	8
9	Anatomical axial CT scan of the pelvis.....	9
10	Anterior view of the pelvis in 3D CT	10
11	Diagram show the different types of Type A Fracture in Tile classification ...	11
12	Diagram show the different types of Type B Fracture in Tile classification ...	12
13	(A) AP (B) & (C) Axial views of Tile B1 Fracture.....	13
14	Diagram show the different types of Type C Fracture in Tile classification ...	13
15	(A)AP (B) Axial CT views of the pelvis With Tile C2 Fracture	14
16	Diagram show the different types of Lateral compression fracture	14
17	AP view Of pelvic (Type I LC fracture)	15
18	Inlet view of pelvic (Type II LC fracture).....	15
19	AP view of pelvic (Type III L C fracture).....	15
20	Diagram show the different types of AP Compression fracture	16
21	AP view of Type II APC fracture.....	16
22	Axial CT Type III AP compression fracture	17
23	Diagram show the Vertical shear fracture Type.....	17
24	(A) AP view of pelvic (B) Axial CT of the pelvic with VS fracture Type	17
25	AP view of Vertical shear fracture of the pelvis	18
26	A) Combined fracture pattern. (B) AP and lateral compression. Fractures of the left pubic rami, lateral compression, but disrubtion of the left sacroiliac joint, indicating AP compression	18
	AP Radiograph of nirmal adult pelvis	19

Figure		Page
27	(A) Inlet view of the pelvis. (B) Outlet view of the pelvis.....	20
28	(A) Inlet (B) outlet (C) lateral views of the pelvic	21
29	(A) AP view. (B) Inlet view. (C) + (D) + (E) axial view (F) + (G) + (I) 3D CT images of Vertical shear case	23
30	A 16 years old male with lateral compression pelvic fracture (Young classification), type B2 (Tile classification) caused by Falling from height....	33, 34
31	A 23 years old male with lateral compression pelvic fracture (Young classification), type C1 (Tile classification) caused by road traffic accidents .	35, 36
32	A 35 years old female with anteroposterior compression pelvic fracture (Young classification), type B3 (Tile classification) caused by road traffic accidents	37,38
33	A 23 years old male with lateral compression pelvic fracture (Young classification), type C1 (Tile classification) caused by road traffic accidents .	39,40
34	A 30 years old male with vertical shear pelvic fracture (Young classification), type B2 (Tile classification) caused by falling from height.....	41

LIST OF ABBREVIATIONS

AP	: Anteroposterior view
APC	: Anterior-Posterior Compression
CM	: Combined Mechanism
CT	: Computed Tomography
Kvp	: Kilo Volt Peak
LC	: Lateral Compression
Lig	: Ligament
MA	: Milli Ampere
MDCT	: MultiDetector Computed Tomography
MPR	: Multiplanar Reconstruction
MM	: Milli Meter
MS	: Milli Second
MSCT	: Multi-slice computer tomography
MRI	: Magnetic Resonance Imaging
PA	: Posterior-Anterior
PRD	: Pelvic ring disruption
RTA	: Road Traffic Accidents
SI	: Sacroiliac joint
ST	: Sacrotuberous
SS	: Sacrospinous
SP	: Symphysis Pubis
VR	: Volume Rendering
VS	: Vertical Shear
3-D	: Three-dimensional

INTRODUCTION

Pelvic fracture is a serious injury that is associated with significant morbidity and mortality. This is a result of the high energy transfer to the pelvic region. Road traffic accidents and falls from height are by far the most common mechanisms of injury.⁽¹⁾ Where the incidence in Motor vehicle crash is (50-60%), Motorcycle crash (10-20%) Pedestrian versus car is (10-20%) Falls from height is (8-10%) and Crush is (3-6%).⁽²⁾

Fractures of the pelvic ring have been reported to comprise 2% to 8% of all skeletal injuries.⁽³⁻⁵⁾ Patients are most often young males in their early 30s, and motor vehicle collisions are the most common inciting cause.^(6,7) Because of the high energy involved, patients with pelvic ring disruptions usually have multiple injuries.⁽⁶⁾ Morbidity and mortality is also high, with overall mortality rates of 17% for patients with pelvic fractures.⁽⁷⁾

Pelvic fractures are frequently complex and the precise pathological anatomy is not easily demonstrated by routine radiographs.⁽⁸⁾ Plain radiographs alone have limited sensitivity for detection of pelvic fractures compared with CT.⁽⁹⁾ Fractures of the sacrum and acetabulum are most easily overlooked.^(8, 9)

Digital radiography and Computed Tomography are valuable for evaluating pelvic fractures.⁽¹⁰⁾ In most poly trauma patients, the first imaging study today is MDCT. Although axial CT images have a higher diagnostic accuracy in detecting and characterizing pelvic injuries than radiography, evaluation with MPR images has been shown to increase diagnostic accuracy.⁽¹¹⁾ Pelvic trauma is where 3-D imaging first made a significant clinical impact, and it is now a standard requisite for surgical planning, being a valuable complement to axial and MPR images.⁽¹²⁾

Normal anatomy

The bony pelvis consists of a ring formed by the paired bones (ilium, ischium, and pubis), the sacrum and the coccyx. The ring is completed by the paired sacroiliac joints posteriorly and the pubic symphysis anteriorly.⁽¹³⁾

The paired bones are composed of three parts: the ilium, ischium, and pubis. These meet at the triradiate cartilage, visible in the immature skeleton as a Y-shaped irregular lucency at the acetabulum.⁽¹³⁾

The ilium is a curved, flat bone with the iliac crest superiorly. At either end of the crest are the anterior and posterior superior iliac spines. Below these lie the anterior and posterior inferior iliac spines, respectively.⁽¹³⁾

The ischium has a body with a tuberosity inferiorly. From this, the ischial ramus runs anteriorly to join the inferior pubic ramus at a synchondrosis. Posteriorly, the ischial spine divides the greater sciatic notch above from the lesser sciatic notch below.⁽¹³⁾

The pubis consists of a body and superior and inferior rami⁽¹³⁾ (Fig 1)

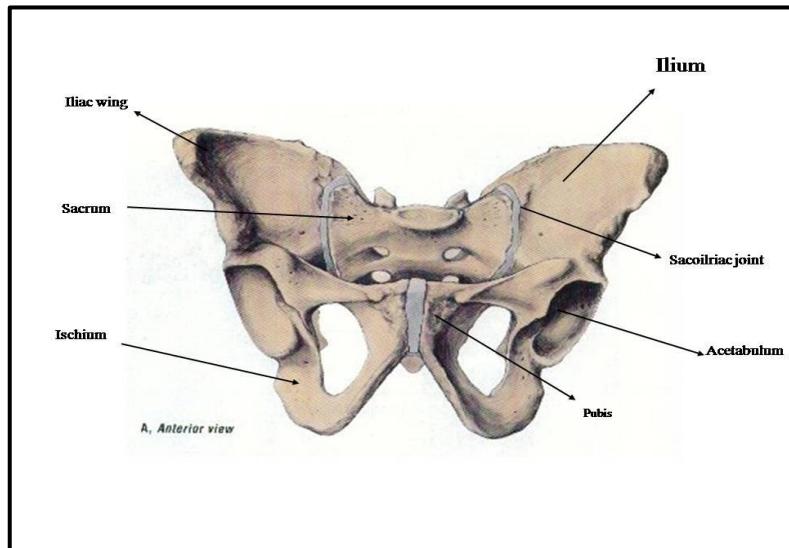


Fig. (1): Normal pelvis anatomy⁽¹⁴⁾

The plane of the pelvic inlet separates the greater pelvis (part of the abdominal cavity) from the lesser pelvis (pelvic cavity). The anterior superior iliac spine and the anterior aspect of the pubis lie in the same vertical plane, the sacrum is located superiorly, the coccyx posteriorly and the pubic symphysis anteroinferiorly⁽¹⁴⁾ (Fig 2).

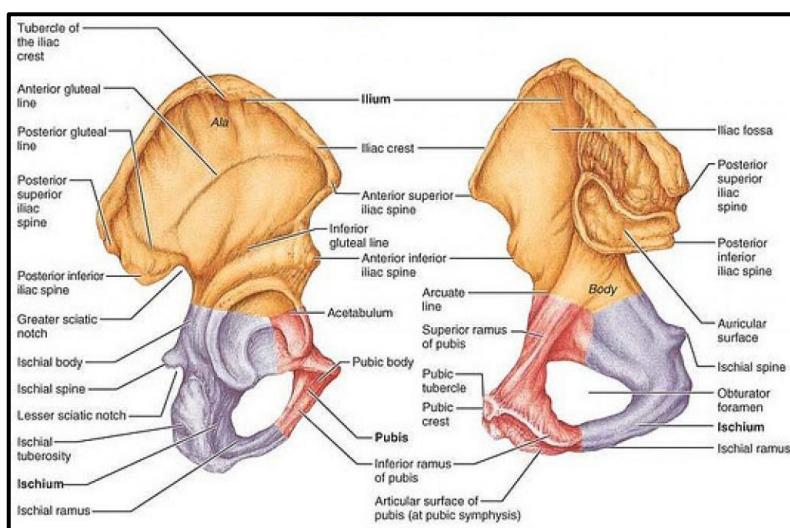


Fig (2): Bony and Parts of the pelvis⁽¹⁴⁾

The acetabulum is supported by two columns: (1) larger anterior column and (2) smaller posterior column. The two columns form an inverted “Y” to support the hip^(15,16) (Fig.3)

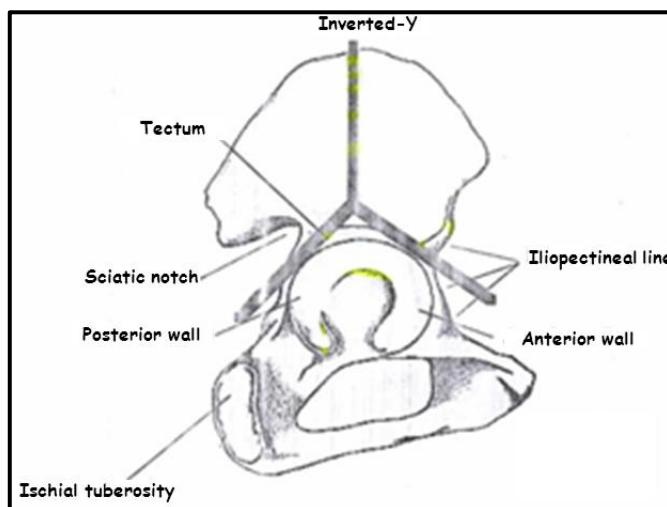


Fig. 3: Normal acetabular anatomy⁽¹⁶⁾

The anterior column begins at the inferior pubic ramus and extends well above the acetabulum into iliac wing. The posterior column is composed predominantly of the ischium and extends to the greater sciatic notch and the sacroiliac joint below the acetabulum, the anterior and posterior columns are joined at the Ischiopubic junction.⁽¹⁷⁾

The medial wall of the acetabulum is called the quadrilateral plate and consists of a thin layer of bone separating the hip joint from the pelvis. Posteriorly, the sacrum articulates with the iliac bones at the sacroiliac joints.⁽¹⁸⁾

The posterior and interosseous sacroiliac ligaments form the so called posterior hinge or posterior tension band, which resists vertical translation of the ilia on the sacrum and is essential to pelvic stability⁽¹⁶⁾ (Fig 4).

The normal width of sacroiliac joint (SI) space is 2.5-4mm. Anterior and posterior sacroiliac ligaments (SI) bridge the sacroiliac joints (SI). The posterior sacroiliac ligaments are quite thick whereas their anterior counterparts are much thinner. In addition, the iliolumbar ligaments connect the posterior iliac crest to the transverse process of L5. The sacrotuberous (ST) and sacrospinous ligaments (SS) connect the inferior aspect of the sacrum to the ischial tuberosity and ischial spine respectively⁽¹⁹⁾ (Fig.4).

The medial end of the pubes articulates to from the pubic symphysis, bridged by superior and arcuate pubic ligaments. The inferior pubic rami, as they diverge from the symphysis form the pubic arch. The pubic and ischial rami fuse to form the obturator ring.⁽²⁰⁾

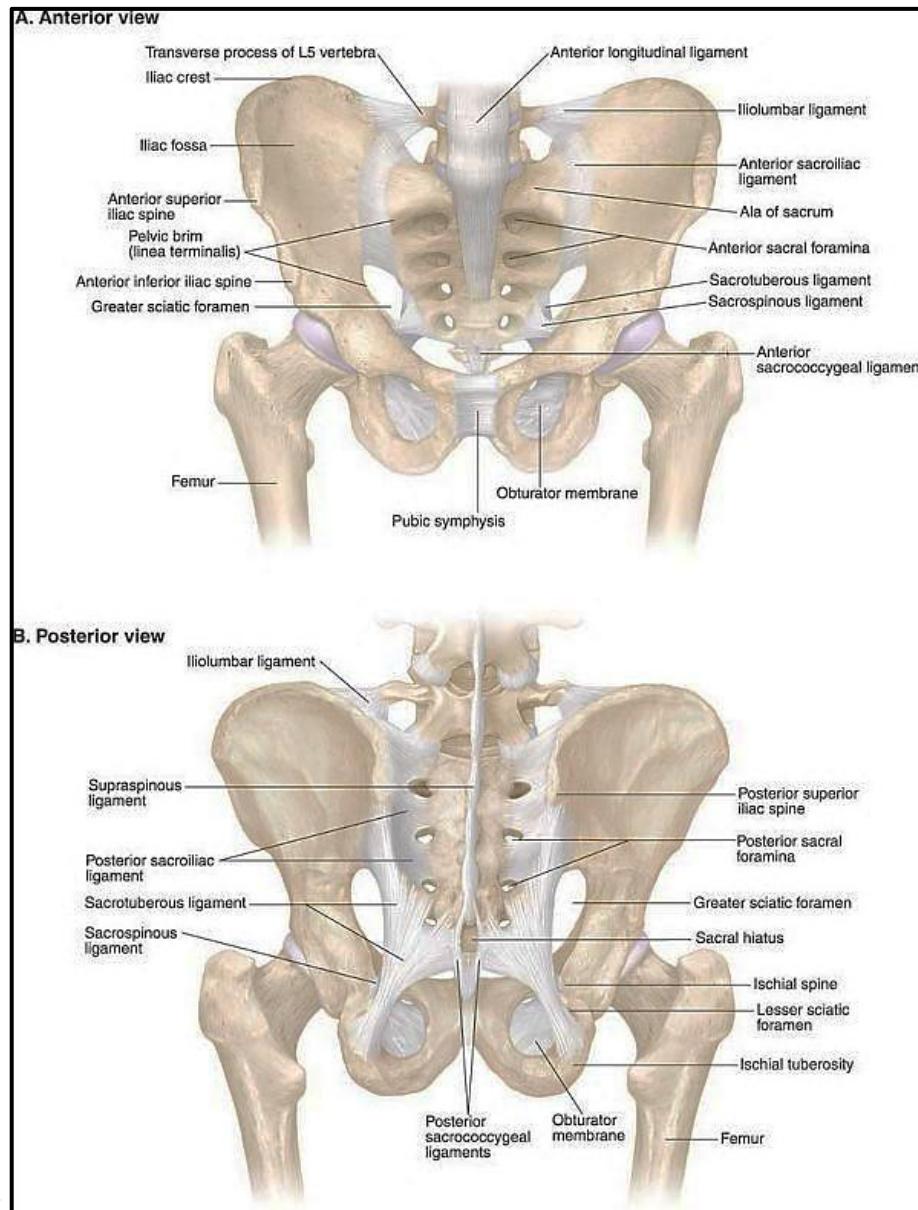


Fig. (4): Ligament of the pelvis (Ant. Post.)⁽¹⁴⁾

The female pelvic girdle is relatively wider and shallower than that of the male, related to its additional roles of bearing the weight of the gravid uterus in late pregnancy, and allowing passage of the fetus through the pelvic outlet during childbirth (parturition).^(14,21) (Fig 5)

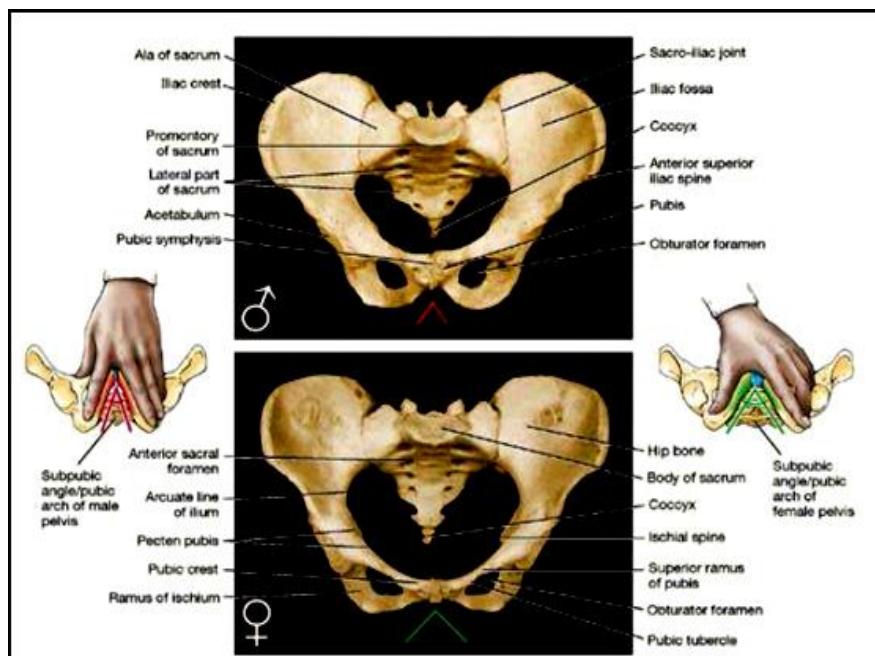


Fig. (5): Comparison of male and female pelvis.⁽²¹⁾

A routine anteroposterior view of the pelvis is taken with the patient in the supine position and with the cassette underneath the tabletop. A somewhat distorted view of the lower part of the sacrum and coccyx is obtained, and these bones may be partially obscured by the symphysis pubis. A better view of the sacrum and coccyx can be obtained by slightly tilting the x-ray tube. An anteroposterior radiograph should be systematically examined. The lower lumbar vertebrae, sacrum, and coccyx may be looked at first, followed by the sacroiliac joints, the different parts of the hip bones, and finally the hip joints and the upper ends of the femurs. And soft tissue shadows of the skin and subcutaneous tissues may also be visualized.⁽²²⁾ (Fig 6)

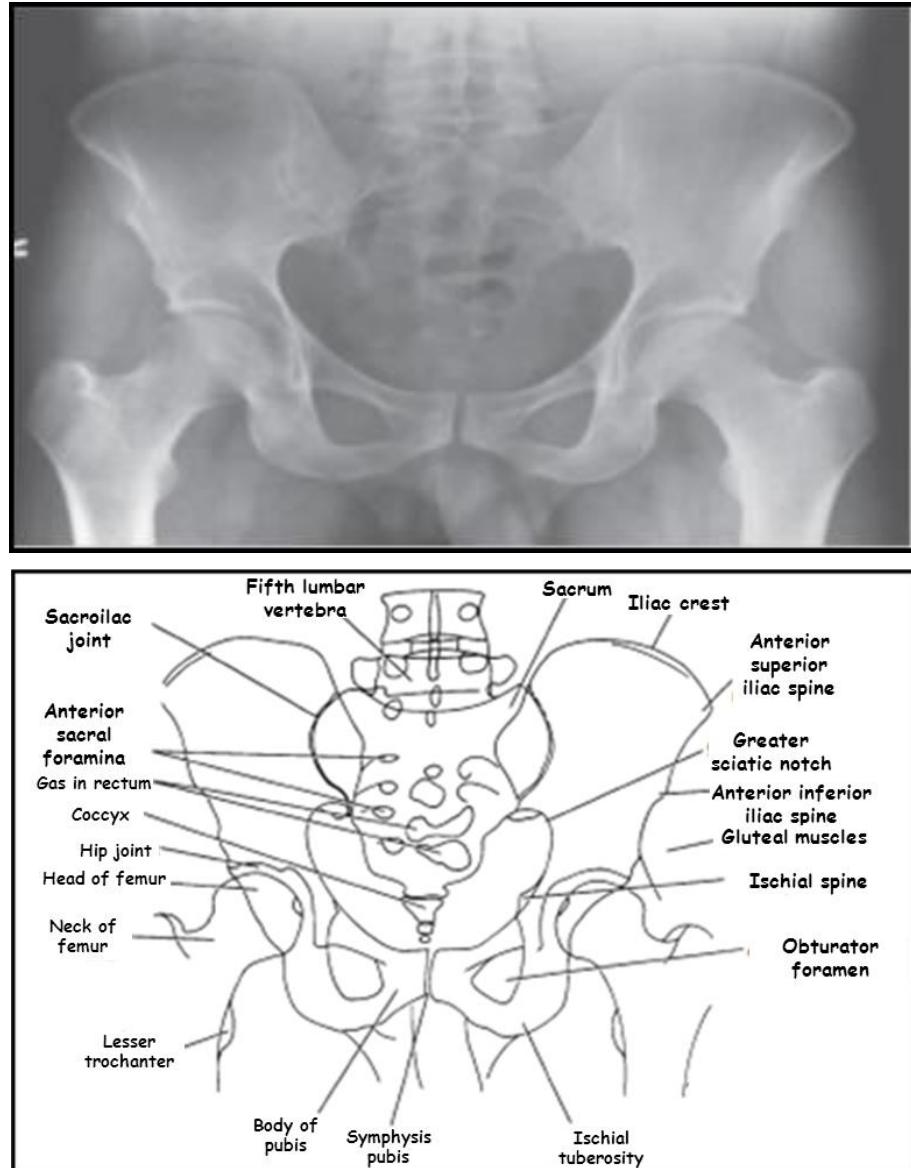


Fig. (6): Representation of the radiograph of the pelvis seen in the Anteroposterior radiograph of the pelvis.⁽²²⁾

The pelvis contains convex bony structures, which form borders and surfaces that are difficult or impossible to demonstrate via the standard projections of conventional radiograph. Computed tomography, with its transverse scanning plane, can provide additional images of structural contours that are essential for diagnosis. The horizontal circumferences of the acetabulum and head of the hip joint, including the anterior and posterior borders of the hip joint, are demonstrated in detail. However, the roof of the acetabulum and the upper joint space are masked by partial volume artifacts when scan sections are thick sections of 2-3mm thickness should therefore be scanned for better demonstration of these regions in patients with certain diagnostic problems. In more caueded sections. The image detail of cortical structures increases muscle orientation of the structures becomes axial, and a detailed evaluation of the sacrum is therefore possible. The anterior sacral foramina normally form unequivocal images. The capsule of the hip joint appears on CT scan as a narrow strip of soft tissue that extends from the anterior and posterior acetabular margins and ends directly contiguous with the head⁽²³⁾ (Fig 7,8)

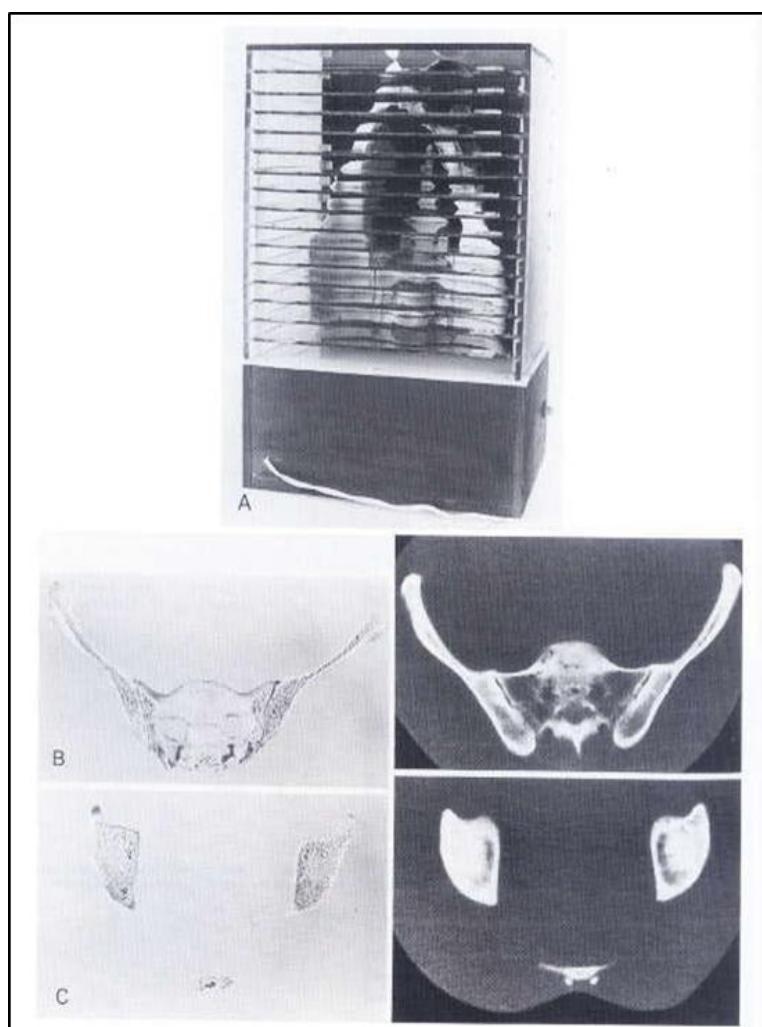


Fig. (7): (a) Embedded in clear acrylic and then sliced, (b) the segment through the sacroiliac joints. (c) Cephalad to the dome of the acetabulum, (d) through the dome of the acetabulum.⁽²⁴⁾

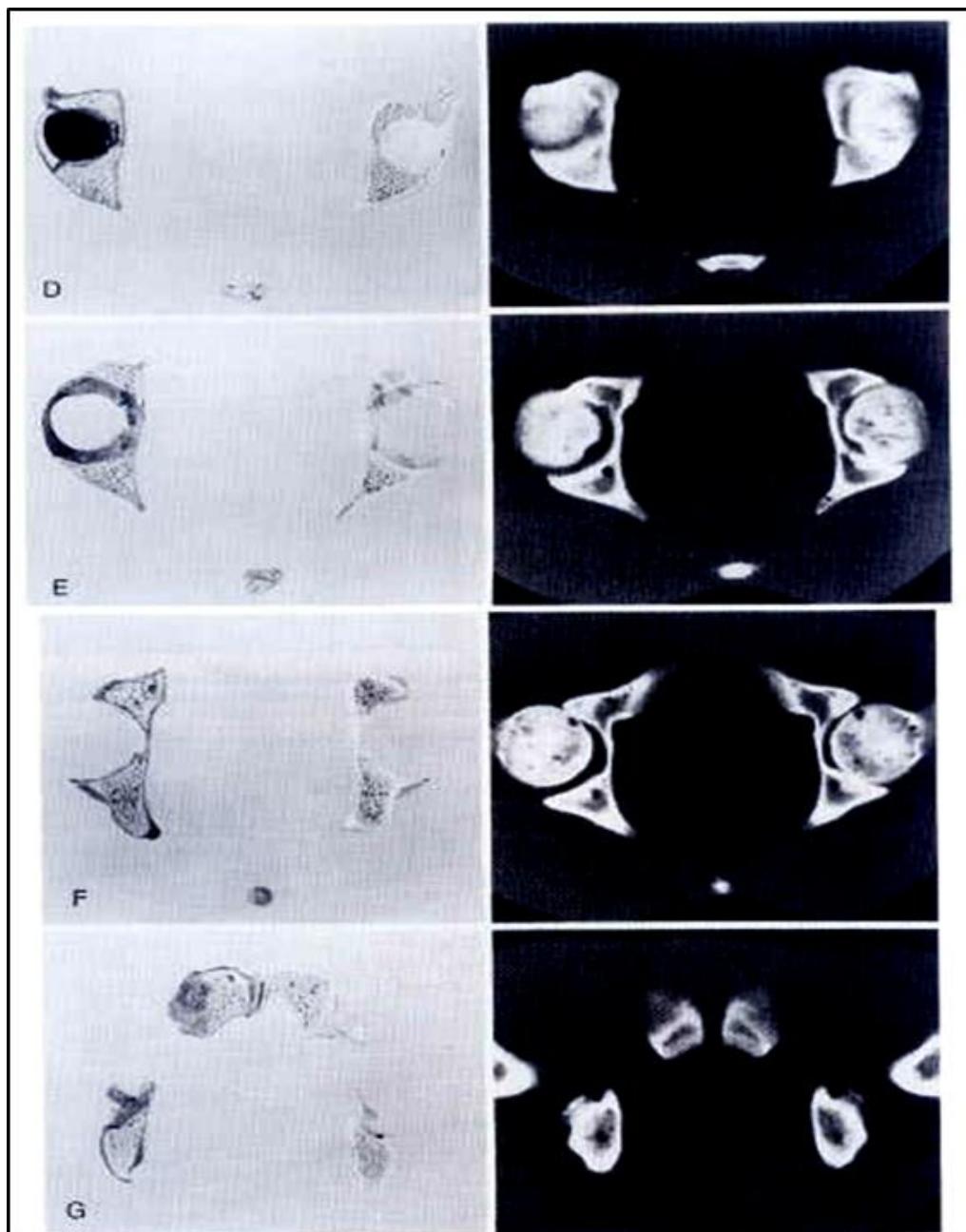


Fig. (7): (d) The articular cartilage of dome is clearly outlined, the anterior column the posterior column. and the medial wall of the acetabulum. (e) Abone slice 1cm from the dome. (f) a slice through the central portion of the acetabulum. (g) The pelvis beyond the acetabulum.⁽²⁴⁾

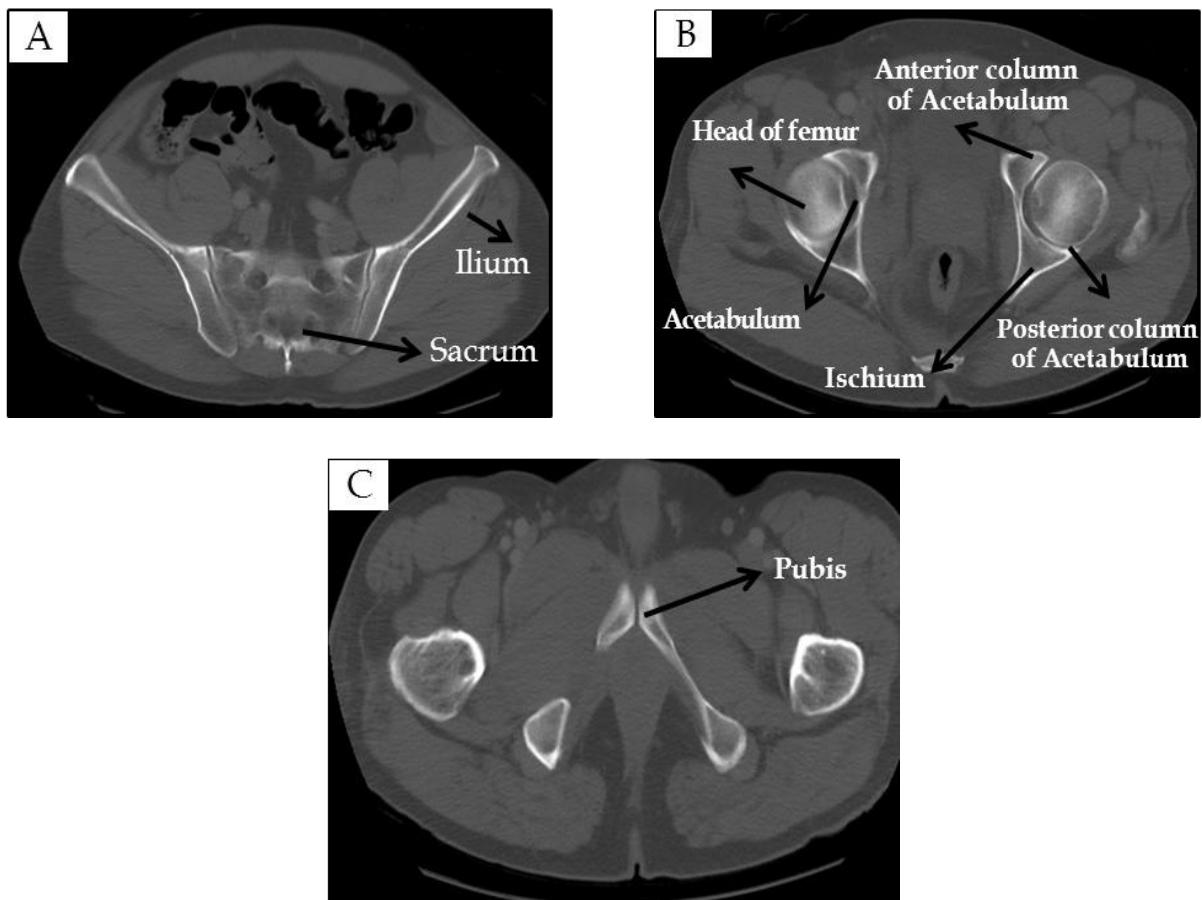


Fig. (8): Anatomical axial CT scan of the pelvis.⁽²²⁾

Because bone attenuates the X-ray beam so much, its CT attenuation value (around +1000 HU) is much greater than that of the surrounding soft tissues. Thus, the bones can be ‘extracted’, with no overlying artifacts, to provide information equivalent to that from a cadaveric skeleton.⁽²⁵⁾ (Fig 9)

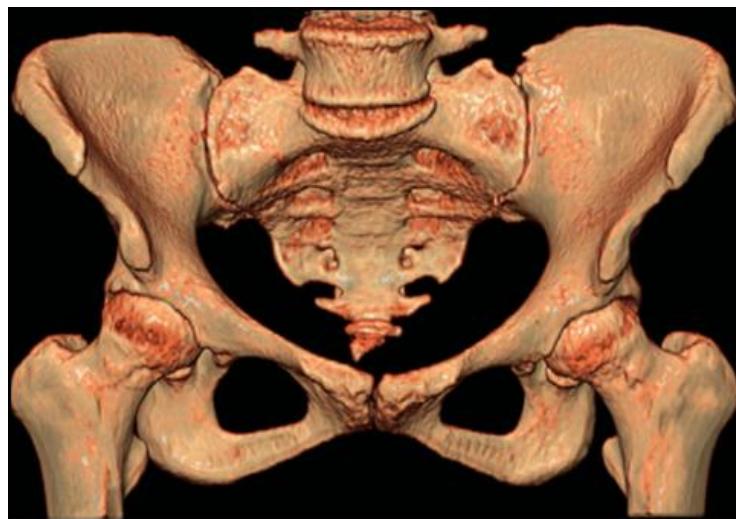


Fig. (9): 3D Computed Tomogram of the pelvis⁽²⁵⁾

Pelvic fracture

Pelvic fractures involve fractures that are, by definition, limited to the pelvic ring (pelvis and sacrum), whereas acetabular fractures (commonly caused by high-impact trauma, such as falls and automobile accidents) are described and classified separately⁽²⁵⁾

Fractures of the pelvic ring have been reported to comprise 2% to 8% of all skeletal injuries³⁻⁶ and are often associated with high-energy trauma, most commonly, motor vehicle accidents and falls from a height. The incidence of pelvic fracture appears to be increasing, secondary to increases in the number of high-speed motor vehicle accidents and the number of patients surviving these accidents, due to airbag and safer car designs.⁽²⁶⁾ Among multiply injured patients with blunt trauma, almost 20% have pelvic injuries.⁽²⁶⁾

Pelvic fractures can either be stable fractures resulting from low energy trauma, for instance iliac wing or isolated ramus fractures, or more importantly, unstable fractures from high energy injury. Most of these results from road traffic accidents, falls from height, or occasionally, workplace crushing accidents.⁽²⁷⁾

Classification of pelvis fracture

Pelvic fractures are common among patients who sustained multiple injuries.⁽²⁸⁾ Sacral injures make up a major component of pelvic ring fractures and reach up to 74% of patient with pelvic fracture.⁽²⁹⁾

Much confusion arisen over pelvic fracture due to lack of a logical and meaningful to classification system. Traditionally, pelvic fractures were classified by reference historical descriptions of individual fractures, without any connection between them. This classification included single fractures of the pelvis and thus was largely outdated by the work of Certzbein and Chenoweth (1977) who demonstrated that there was always a second site of injury even in apparently single pelvic fractures. This is due to the fact that the pelvis is a bony ring, held together by ligamentous groups posteriorly. A search for a second site of injury should therefore always be made in fracture involving the pelvic ring.⁽³¹⁾

The classification system of Young and Burgess (1986) developed from work by Pennal and Tile which describes fractures relative to the force of injury.

Tile classification

Tile (1980) further proposed a classification system using radiographic criteria to decide which injuries are mechanically stable and which are not, and therefore which pelvic injuries require stabilization and which can be managed nonoperatively. He divided pelvic ring injuries into types A, B, and C. With type A injuries, the pelvic ring is still intact; with type B injuries, the ring is rotationally unstable but vertically stable; and with type C injuries, both rotational instability and vertical instability of the pelvis are present.⁽³²⁾

1- Type A (stable)

Type A fractures are stable, and are not pelvic ring disruptions. Small chip or avulsion fractures of the innominate bone are termed Type A1 fractures. Stable, minimally displaced fractures of the pelvic ring or iliac wing fractures are termed Type A2 injuries. Type A3 injuries are transverse sacrum or coccygeal fractures.⁽³³⁾ (Fig 10)

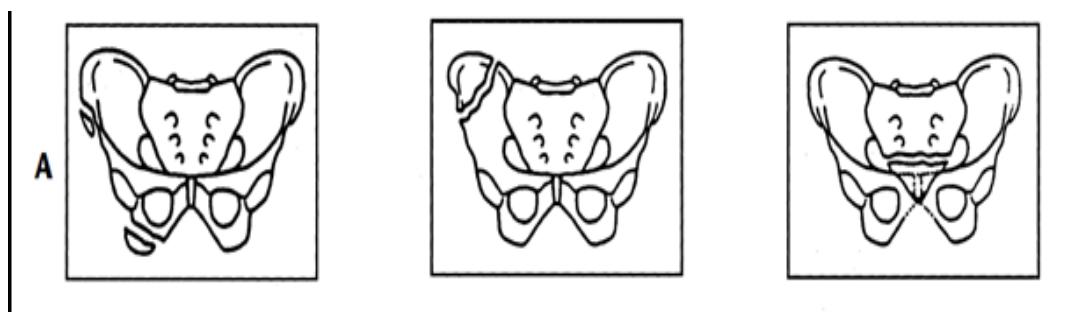


Fig. (10): Diagram show the Type A fractures of the pelvis (stable)⁽³⁴⁾

2- Type B (rotational instability)

Type B fractures are unstable with respect to rotation, but are vertically stable. The simplest example is an open-book fracture (B1) of the pelvis, with pubic symphysis diastasis or obturator ring fractures in the anterior pelvis, and anterior sacro-iliac diastasis in the posterior pelvis (Fig. 12). This fracture pattern is unstable with respect to external rotation, but the posterior sacroiliac ligaments remain intact and provide vertical stability. The second type of rotationally unstable pelvic fractures is LC injuries. These are Type B2

fractures, and involve transverse fractures through the obturator rings and impaction fractures across the sacroiliac joint. Finally, complex pelvic fractures may involve an open-book appearance on one side, but a LC of the opposite side. These bilateral rotational injuries are Type B3⁽³³⁾ (Fig 11).

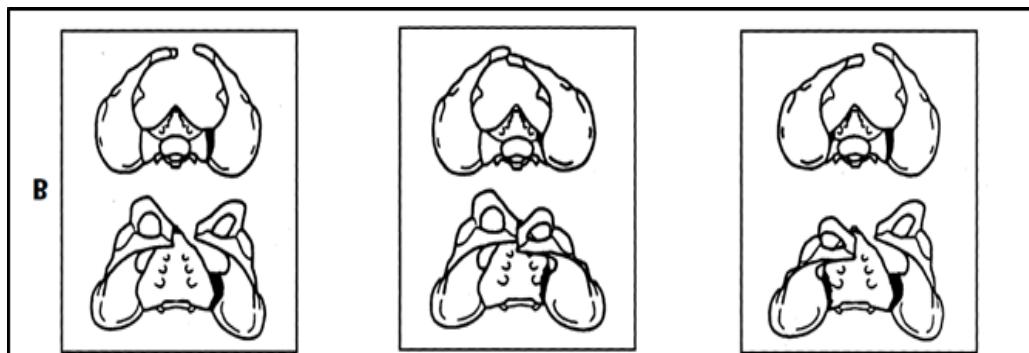
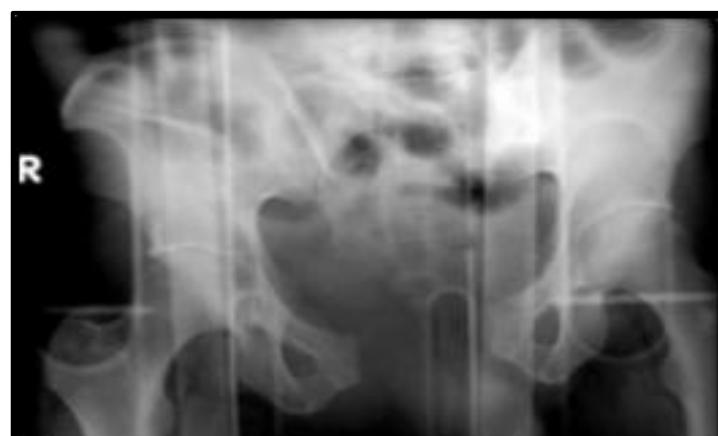
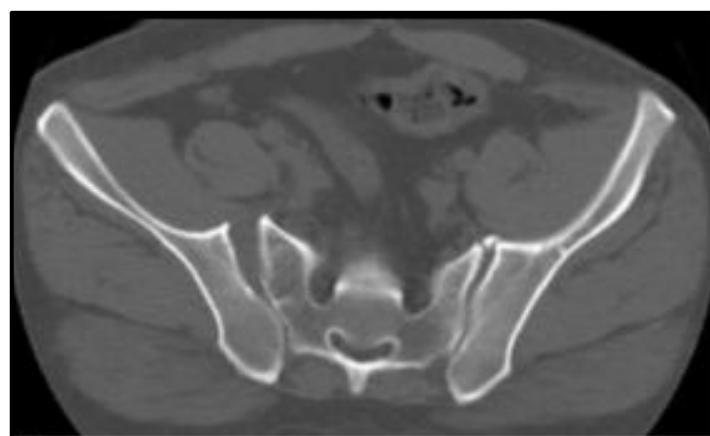


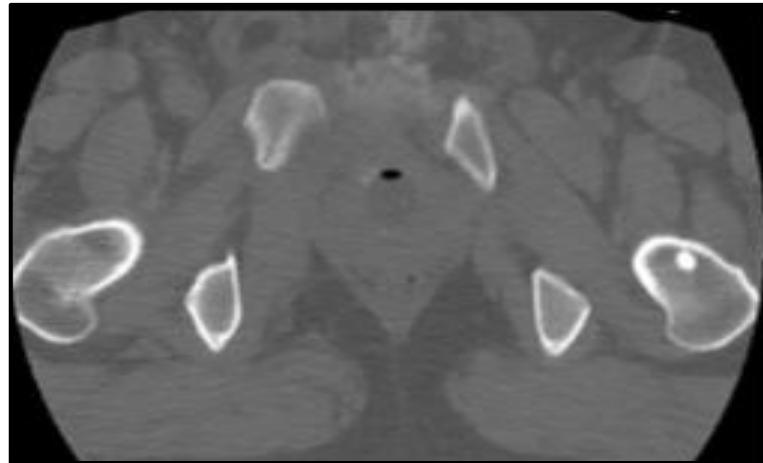
Fig. (11): Diagram show the Type B fractures of the pelvis (unstable).⁽³⁴⁾



(A)



(B)



(C)

Fig. (12): (a) AP radiograph shows greater than 2.5 cm symphysis Diastasis. The posterior SI joints are likely intact, but the anterior right SI joint looks wide; (b) axial CT image demonstrates right anterior SI diastasis and small avulsion fracture of left anterior SI joint indicating anterior ligament injury on this side (c) axial CT image of symphysis diastasis. This Tile B1 fracture is rotationally unstable, but vertically stable. ⁽³³⁾

3- Tile Type C (*rotational and vertical instability*)

Type C fractures are unstable to both rotational and vertical forces and are among the most severe pelvic fractures. Anterior pelvis injuries include vertical fractures through one or both obturator rings. These fractures are often limited to one side of the pelvis, and are then Type C1. More complex patterns exist, and Tile defines additional subcategories for each combination. Type C2 fractures are vertically unstable on one side, and rotationally unstable on the other (Figs14.). Type C3 fractures are vertically unstable on both sides. ⁽³³⁾ (Fig 13)



Fig. (13): Diagram show the Type C fractures of the pelvis (unstable). ⁽³⁴⁾

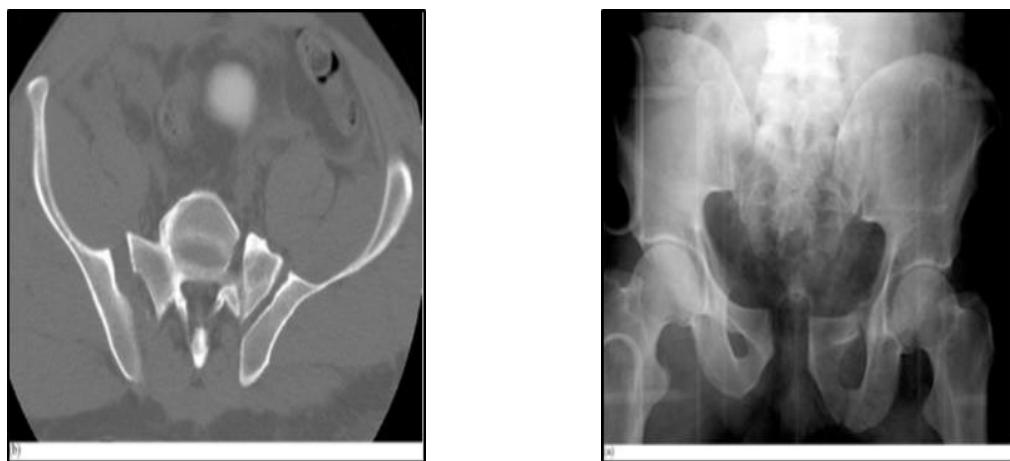


Fig. (14): (a) AP radiograph reveals vertical displacement of the right hemipelvis with a symphysis diastasis, left obturator ring fractures, and right sacroiliac diastasis/disruption; (b) CT confirms right SI diastasis and shows vertical and posterior displacement of right hemipelvis, as well as left anterior SI diastasis. This is a Tile C2 with right vertical instability and left rotational instability⁽³³⁾

Young and burgess classification

Young had expanded Tile's classification and created a classification system to predict the mechanism of injury. The Young-Burgess classification system divides pelvic ring disruptions into 4 major types: anterior-posterior compression, lateral compression, vertical shear, and combined mechanism injury. Based on radiographic appearance, the authors further subdivided anterior-posterior compression injuries into anterior-posterior compression I, II, and III and lateral compression injuries into lateral compression I, II, and III⁽³²⁾

1- Lateral compression fractures

These are subdivided into three types depending upon the severity of the injury, and progressive involvement of the posterior pelvis (Fig. 15). Pubic rami fractures are invariably present and generally run horizontally, or in the, coronal plane. Alternatively they may present as a buckle fracture. A common association is a crush fracture of the sacrum. Fracture of the medial wall of the acetabulum with or without central dislocation of the femoral head is also associated.⁽³⁵⁾

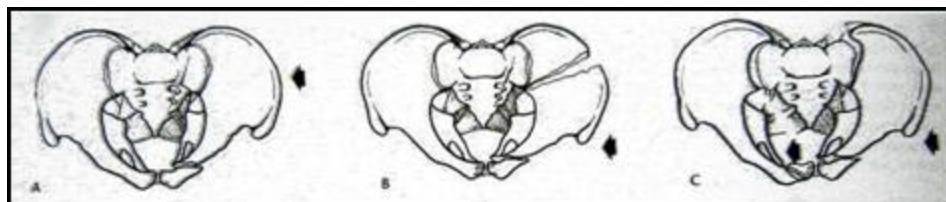


Fig. (15): Lateral compression pelvic fracture classification. Posteriorly lateral force causes compression of the sacrum, or buckle fractures of the pubic rami. The force is delivered more anteriorly, causing inward rotation of the anterior pelvis around the anterior aspect of the sacroiliac joint. Fracture of the iliac wing (shown here). (C) Type III. The lateral force on one side is transmitted to the contralateral side, causing an externally directed force to 'open' the contralateral pelvis⁽³⁵⁾

Type I: Fractures there is no ligamentous damage, and no posterior pelvis instability. (Fig 16)

Type II: Fractures there is medial displacement of the anterior pelvis on the side of injury with either a fracture through the sacroiliac joint and iliac wing, or rupture of the posterior sacroiliac ligaments (Fig.17) this allows some posterior instability.

Type III: Fractures, the lateral force on one side of the pelvis is transmitted through to the contralateral side, so that the fracture is directed outward .This causes "opening" of the pelvis on the contralateral, side, with associated posterior ligamentous disruption AP compression fracture⁽³⁵⁾ (Fig.18).



Fig. (16): Type I lateral compression fracture. A horizontal fracture of the left (closed arrow) and a buckle fracture of the right (open arrows) superior pubic ramus are seen. There is a crush fracture of the left sacrum (long arrows), and a fracture predominantly of the medial wall of the left acetabulum.⁽³⁵⁾

Fig. (17): Type II B lateral compression fracture. 'Horizontal' fracture of the right symphysis, and oblique fracture of the left iliac wing. There is moderate medial displacement of the left anterior pelvis.(Reproduced with permission of Urban and Schwartzenberg from Young and Burgess (1987)⁽³⁵⁾)



Fig. (18): Lateral compression Type III. There are crush fractures of the right sacrum (closed arrow) and left pubic rami. Sacroiliac joint (open arrow) and lateral displacement of the whole of the anterior pelvis to the left, Fractures of the right pubic rami are also seen.⁽³⁵⁾

AP compression fracture

The damaging force in the AP or (PA) direction tends to cause "opening" of the anterior pelvis (Fig. 19), with splaying of the symphysis pubis (SP) and or fractures of the pubic rami. Which however, are in the vertical plane, in contrast to lateral compression fractures. The more sever type II and III fractures relate to increasing posterior ligamentous injury and hence increasing instability⁽³⁵⁾ (Fig 20).

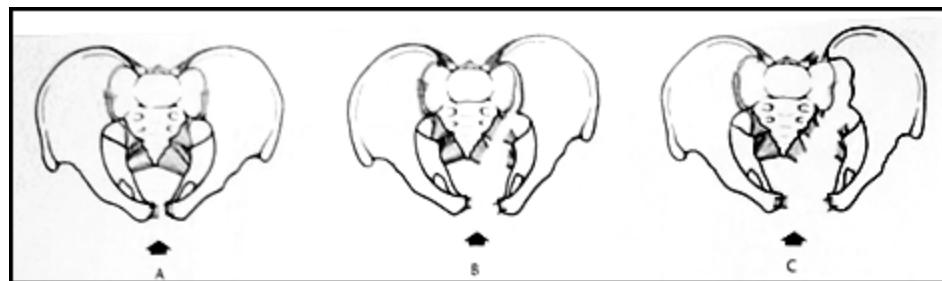


Fig. (19): Anteroposterior (AP) compression fracture classification. I. Diastasis of the symphysis pubis only. Type II. Diastasis of the symphysis pubis, disruption of the sacrospinous and sacrotuberous ligaments, and anterior sacroiliac ligament. Type III. Total ligamentous disruption, including the posterior sacroiliac ligaments.⁽³⁵⁾



Fig. (20): Type II AP compression fracture. There is wide diastasis of the symphysis pubis and anterior left sacroiliac joint.⁽³⁵⁾

In type II fractures, the anterior sacroiliac, (SI) sacrospinous (SS) and sacrotuberous (ST) ligaments are disrupted, allowing wide splaying of the anterior pelvis.

Type III fractures, there is total disruption of sacroiliac joint (Fig.21) fractures of the anterior and posterior acetabular pillars are common, and posterior hip dislocations are also associated, in contrast to lateral compression fractures, when the medial wall of the acetabulum is at risk.⁽³⁵⁾



Fig. (21): Type III AP compression fracture. CT scan demonstrates complete diastasis of the left sacroiliac joint.⁽³⁵⁾

Vertical shear fractures

These commonly result from falls from a height fractures occur though the pubic rami and posterior pelvis. And are vertically oriented (Fig.22). The large lateral hemipelvic fracture fragment containing the acetabulum is displaced superiorly.

Fractures of the posterior and superior acetabula are often associated with superior displacement of the femoral head. These injuries are associated with fractures of the lumbar vertebrae and calcaneus.⁽³⁶⁾ (fig.23)

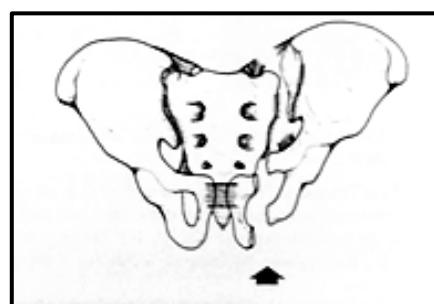


Fig. (22): Vertical shear fracture pattern. A superiorly directed force disrupts the left hemipelvis, with diastasis through the left sacroiliac region.⁽³⁵⁾

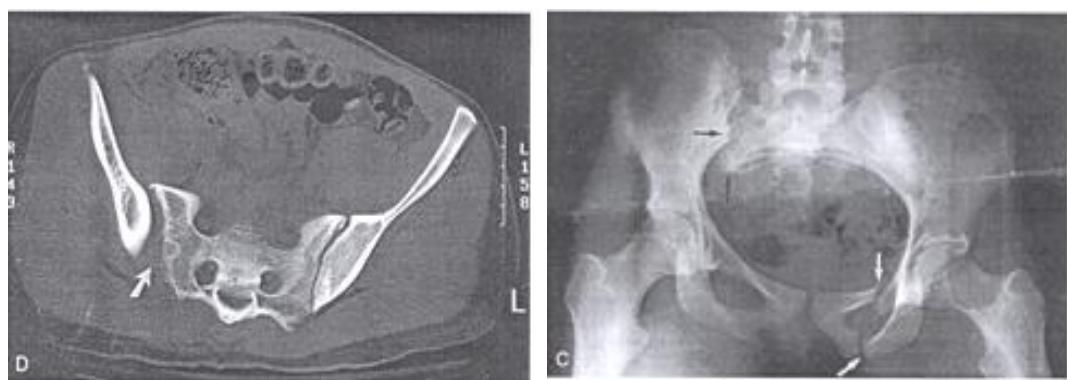


Fig. (23): AP pelvis shows dislocation of the right sacroiliac joint (black arrows) and contralateral obturator ring fractures (white arrows). The right hemipelvis is displaced superiorly on the sacrum. D, Direct coronal CT scan shows the sacroiliac dislocation (arrow).⁽¹⁶⁾



Fig. (24): Vertical shear pattern. A, AP pelvis shows left sacral (black arrows) and ipsilateral obturator ring (white arrows) fractures. The left iliac crest and hip are displaced superiorly compared with the right, the radiographic hallmark of the vertical shear injury pattern. B, Direct coronal CT scan of the sacrum shows the comminuted fracture (closed arrows) and superior displacement of the left ilium (open arrow).⁽¹⁶⁾

Mixed fracture pattern

These arise from a combination vector of the forces causing injury and give rise to a mixed pattern of fracture, the commonest being a mixed antero-lateral pattern (Fig.25), with signs of both AP and lateral compression.⁽³⁵⁾

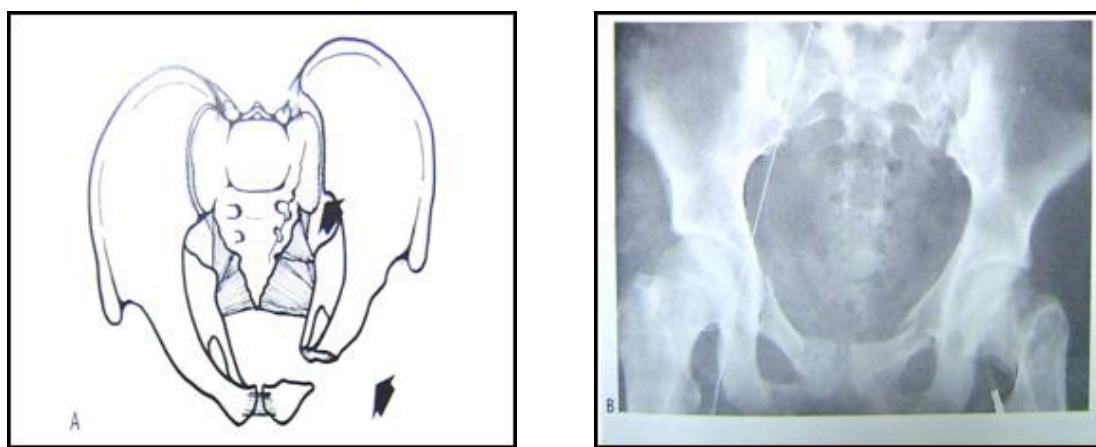


Fig. (25): A) Combined fracture pattern. (B) AP and lateral compression. Fractures of the left pubic rami, lateral compression, but disruption of the left sacroiliac joint, indicating AP compression⁽³⁵⁾

Plain radiography

Plain radiographs are the initial means of evaluating a patient with suspected pelvic fracture an AP view of the pelvis is one of the film that every traumatized patients receives on admission⁽¹⁶⁾ (Fig 26)



Fig. (26): AP radiograph of a normal adult pelvis: The principal skeletal anatomic landmarks include the sacroiliac joint (curved arrow), sacral arcuate lines (small white arrows), ilioischial line (black arrows), iliopectineal line (large white arrows), pubic symphysis (open arrow) and obturator foramen (asterisk).⁽³⁷⁾

The vast majority of diagnosis can be made correctly by using (AP) radiograph alone. The inlet view of the pelvis (a view of the pelvic inlet with the patient supine, the x-ray tube angled 35C° caudally and beam centered mid-way between the (umbilicus and pubic symphysis) is of use for several reasons. It may demonstrate subtle compression the expansion of the pelvic ring seen in lateral or AP compression. It may also demonstrate the coronal nature of pubic rami fractures that appear vertically oriented on the AP view, enables us indicating of the effects of a lateral compression force. The inlet view identification of the sacrum fractures that is not identified on the AP view.⁽³⁸⁾ (fig.27)

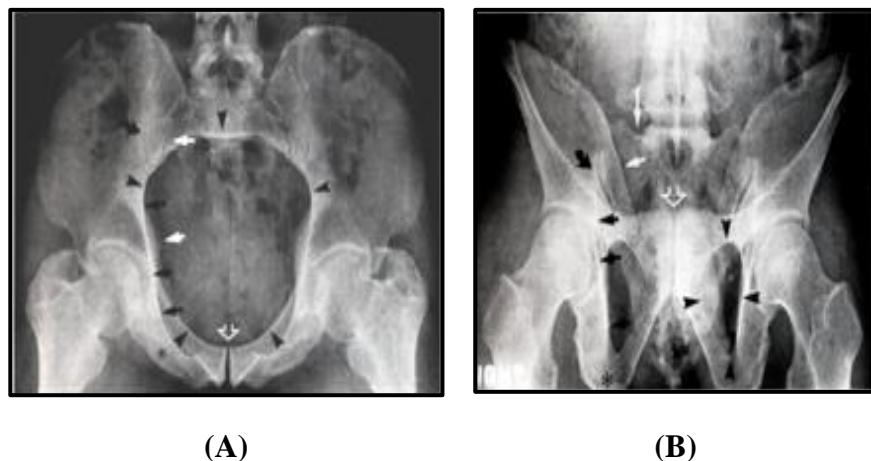


Fig. (27): The inlet view (A) This projection shows the pelvic ring (plane of the inlet to the true pelvis (arrowheads), the anterior (curved arrow) and posterior (short white arrow) margins of the sacroiliac joints, the ilioischial line, (black arrows), the ischial tuberosity (asterisk), the ischial spine (white arrow) and the symmetry of the pubic symphysis (open arrow) and the symmetry of the pubic symphysis (open arrow). The outlet view (B) including the ala (long white arrow), the anterior (curved arrow) and posterior (short white arrow) margins of the sacroiliac joint (curved arrow), the ilioischial line (black arrows) and pubic symphysis (open arrow) in different, and the margins of the obturator foramen (arrowheads).⁽³⁷⁾

The outlet view of the pelvis (a view of the pelvic outlet with the patient supine and the x-ray tube angled 35°C cephalad and the beam centered on the superior margin of the pubic symphysis) although it is not diagnostic of any pelvic fracture, it provides an indication of vertical displacement of the fracture fragment in cases of vertical shear. This is of some importance to surgeon in planning corrective treatment.⁽³⁸⁾ (Fig 28)

Unlike bones that may fracture in response to any type of deforming force. Ligaments fail only in tension. The pelvic ligaments play a critical role in normal pelvic stability and in stability after pelvic fractures.⁽³⁹⁾

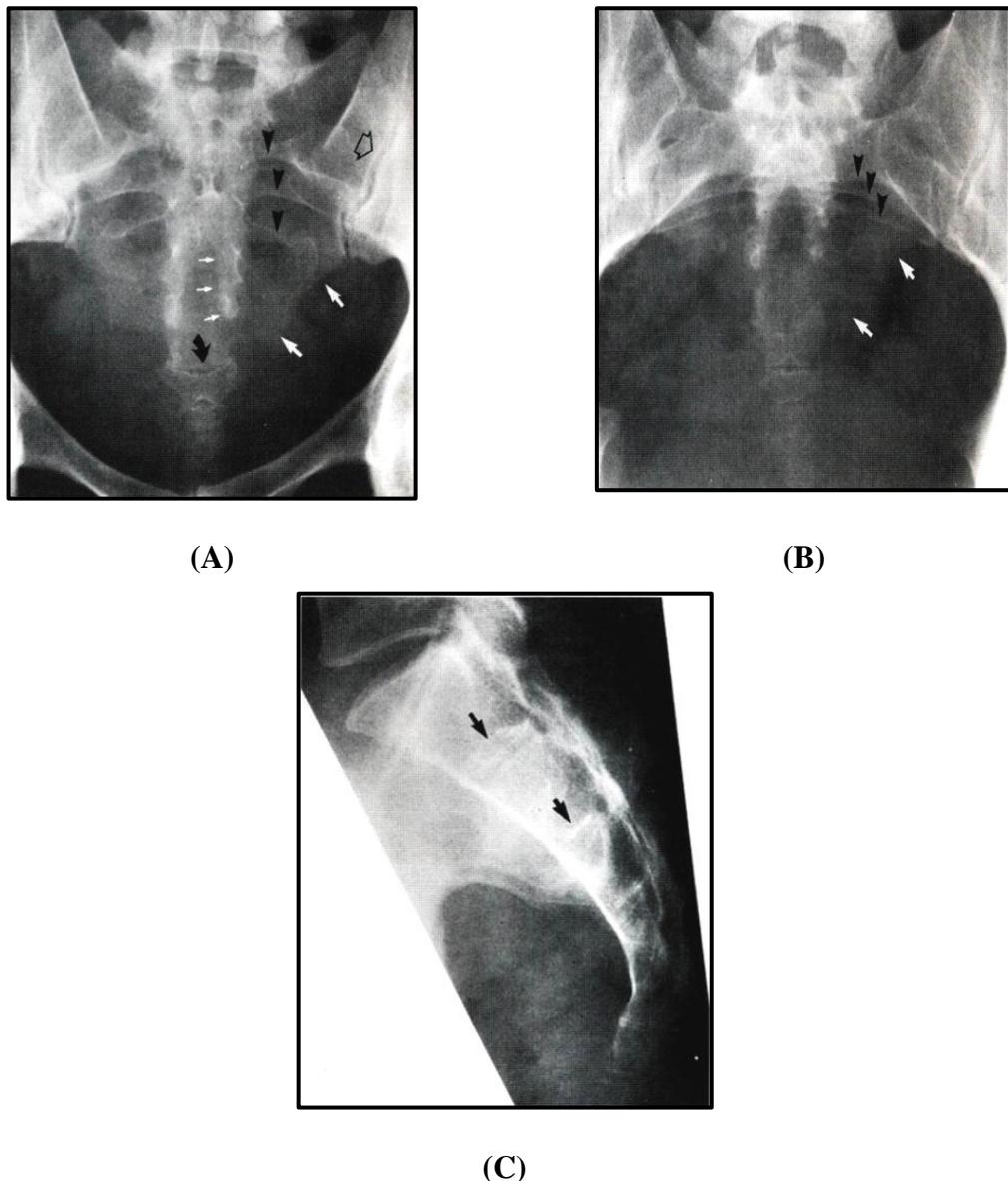


Fig. (28): Shows the superior margin of the ala (broad arrow), the normal sacral arcuate lines (arrowheads), the sacroiliac joint (open arrow), the lateral margin of the lower sacral segments (white arrows), the sacrococcygeal joint (curved arrow), and adjacent coccyx. The small white arrows mark the lateral margin of commonly unfused sacral crest. The radiograph obtained with the central beam angled caudally shows the arcuate lines (arrowheads) and the lower sacral segments (white arrows). The lateral radiograph is the most useful projection of the sacrum and coccyx. The transverse linear densities represent fused sacral disk spaces.⁽³⁷⁾

Computed tomography

Although plain radiography is indicated for fracture classifications, CT is useful for detecting intra-articular fragments, fragment interposition, marginal impaction, occult pelvic ring fractures and evaluating the sacroiliac complex to determine if vertical instability is present.⁽¹⁶⁾

Multi-planar or reconstructions can facilitate detection and quantification of articular discontinuity, which is often important for deciding between operative and conservative treatment.⁽¹⁶⁾

MSCT has increased the speed, efficiency and accuracy of computed tomographic imaging in musculoskeletal trauma. Added advantages such as MPRs and 3D imaging have greatly enhanced the ability to evaluate complex anatomical areas such as the spine, pelvis and foot.^(40, 41)

Three dimensional reconstruction's of the acetabulum although not usually needed to classify a given fracture a given fracture, do provide important preoperative information for the surgeon who is contemplating open reduction and internal fixation three dimensional rendering can be enhanced by electronic disarticulation prior to reconstruction, as well as reconstructing only the hemipelvis of interest. This minimizes interference by overlapping structures.⁽²⁰⁾

CT scan delineates soft tissue and concomitant injury to soft tissue structures.. CT is particularly effective in the post-surgical assessment of the alignment of fragments and fracture healing.⁽⁴²⁾

The nearly universal application of computed tomography (CT) into the initial assessment of patient with PRD and the increasing use of three dimensional CT (3 D CT) both accurately depict the orientation of components of PRD.⁽³⁷⁾

In the interest of eliminating the unnecessary patients movement required to obtain oblique or tangential views, the AP radiograph of the hips and pelvis should be obtained initially and carefully studied from the point of view that the pelvis in fact, a three dimensional structure only when the AP radiograph of the pelvis is found to be inconclusive should additional views be considered.⁽³⁷⁾

The routine radiographic examination of the sacrum and coccyx alone must include a straight AP projection and a true lateral radiograph of the sacrum and coccyx However, in the context of PRD, CT best demonstrates sacral and sacroiliac anatomy and traumatic pathology is best demonstrated by CT.⁽³⁷⁾

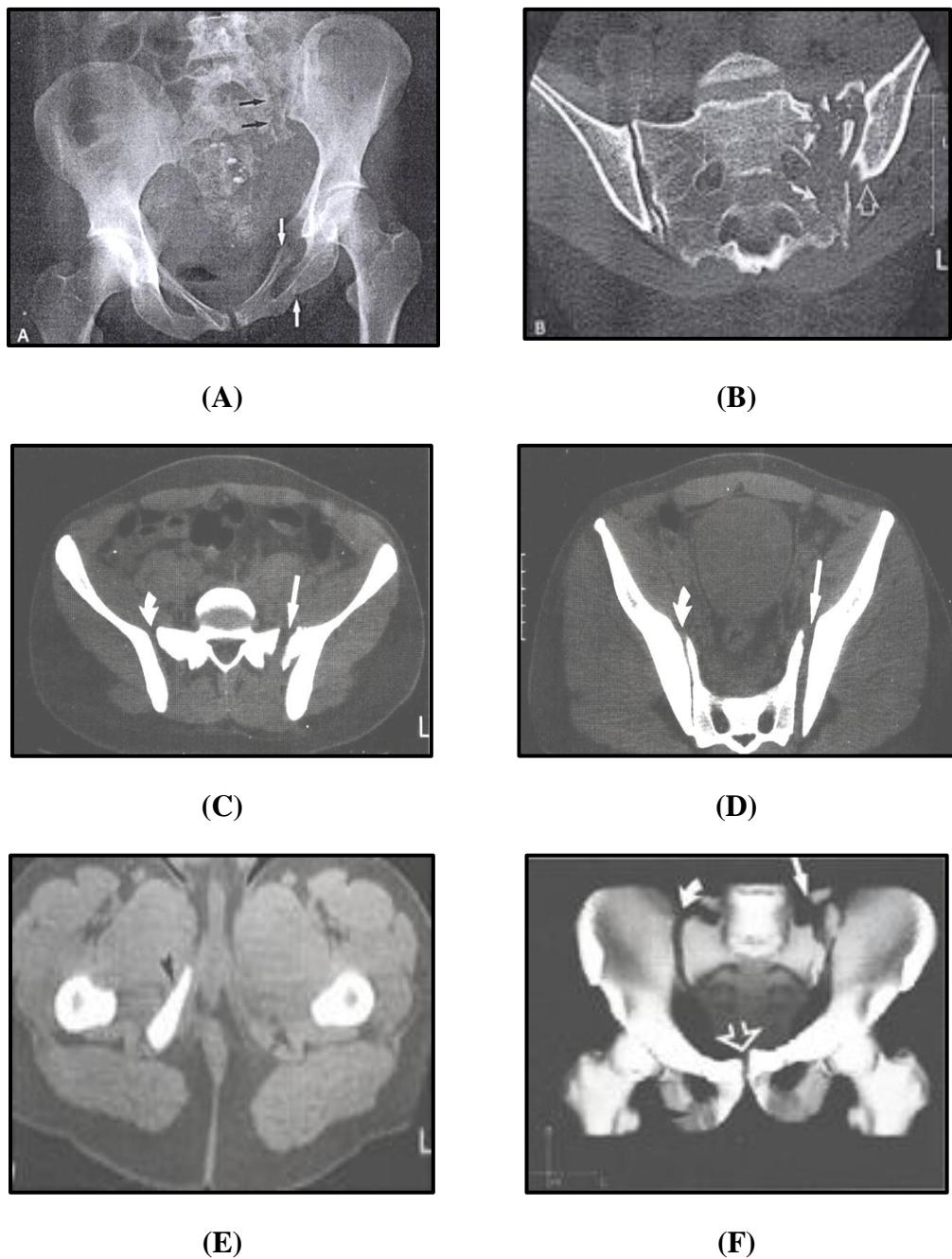


Fig. (29): Pubic diastasis, is evident on both AP (A) and inlet (B) views. Of two posterior sites of disruption the left sacroiliac joint separation-alar fracture (straight arrows) is easily recognized but the right sacroiliac joint separation (curved arrow) could easily be overlooked Axial CT clearly demonstrates the bilateral sacroiliac joint diastasis and the left sacral alar fracture (C and D) and confirms the right inferior public ramus fracture (arrowhead, E), The 3D CT images in frontal (F).⁽³⁷⁾

Many authors reported that 10-31% of sacroiliac joint diastasis were misdiagnosed on plain film interpretations.⁽⁴³⁾

With CT, all joint diastases were detected. Intra-articular gas was not seen on any of the plain films but was detected by CT. An intra-articular fragment was identified only on CT images. Alignment of the diastatic elements was well seen on CT.⁽⁴⁴⁾

Over one half of the fractures were unsuspected on plain radiograph with CT, all fractures were clearly detected. Confirmation of a suspected fracture was aided by CT, and with CT it was possible to delineate the site of origin of the fracture more precisely.⁽⁴⁵⁾

In plain radiographs a high index of suspicion and a conscientious search for minute asymmetry or deformity of the sacral actuate lines may improve the detection of vertical shear fractures.⁽⁴⁶⁾

Plain film interpretation failed to detect 25% of comminuted sacral fractures, with CT, all of these fractures were detected and more CT more clearly depicted the location rotation and dislocation of the fracture fragment. Reformation in a sagittal plane could be useful in delineating the anteroposterior relationships of fragments.⁽⁴⁵⁾

In one third of patient with posterior pelvic injury the initial classification of the pelvic according to the specific Rchanged because of the additional anatomic information provided by the CT scan where some anteroposterior compression injuries were reclassified as lateral compression injuries, and many lateral compression injuries were also reclassified as vertical shear injuries.⁽⁴⁷⁾

Furthermore, Buckley and Burkus in (1987) reported that the classification of pelvic injuries was changed upon the CT scan finding in 67% of cases where these injuries, classified as single breaks in the pelvic ring depending on plain radiographs, were classified as double breaks in the pelvic ring because of identification of occult disruption within the posterior ring structures.⁽⁴⁸⁾

Before the development of three dimensional CT reconstructions, experienced radiologists and orthopedic surgeons attempted to create a mental three-dimensional image after analysis of radiographs and axial CT scans.

Three dimensional CT has the advantage of providing an image that can be viewed and analyzed from many angles including those to be encountered during a given surgical approach. This can best be achieved by manipulation of the three-dimensional volume at the operator workstation. Precise angles and distances can be measured, and hard copies can be generated on film or videotape including dynamic.⁽⁴⁹⁾

Computer subtraction of certain anatomic structures to improve visualization of other structures provides an advantage not available with other modalities.⁽¹⁵⁾

In the acute trauma setting patients motion is difficult to control and may severely compromise three dimensional reconstructions. However, with the use of newer scanners. That 1 to 2 second scanning times, motion artifacts can be reduced. Streak artifacts from metallic or high-density objects such as bullet fragments, external fixation device, or monitoring leads may also compromise CT scans (both two and three dimensional).⁽¹⁵⁾

Three-dimensional images may have computer generated-artifacts surface or edge-detection programs have difficulty in detection of non-displacing fractures or thin osteopenic bone. These artifacts are readily recognized if the three-dimensional image correlated with the original two-dimensional images. Newer volumetric rendering techniques better preserve surface detail with improved visualization of the non-displaced fractures.⁽⁴⁹⁾

Occult injuries identified on CT scanning included sacroiliac joint disruption. Posterior iliac fractures and an avulsion fracture of the ilium at the attachment of the avulsion sacroiliac ligament.⁽⁴⁸⁾

In many cases occult injuries to the contralateral sacroiliac joints were revealed by CT scan unexpected extension of the hemi-pelvic fracture into the acetabulum was made visible by the CT scan.⁽⁵⁰⁾

In contrast, apparent extension of the pelvic ring fractures into the acetabulum, suggested on plain films, can be excluded by CT scanning extension of the pelvic ring fracture into hip joint would change the treatment of the fracture and mobilization of the patient.⁽⁴⁸⁾

A high rate of injuries that originally had been classified as stable on plain radiographs were reclassified as unstable following CT scan demonstration of marked posterior pelvic ring injuries. CT can show severe comminution of the sacrum or of the sacroiliac joint and can demonstrate previously unsuspected posterior displacement of the ilium at the sacroiliac joint. These findings influenced the treatment in the majority of the cases where internal fixation of sacroiliac joint disruption may not be possible with excessive comminution of the sacrum and anterior stabilization of the pelvis with an external fixation device or bed rest and traction may be only alternative.⁽⁴⁸⁾

3D-CT images best showed the plane of the fracture, which can be difficult to assess on Axial CT images. Determining the precise plane of the fracture is important for planning the surgical approach.⁽¹⁵⁾

3D-CT images provided further insight into the degree of disruption of the articular surface and spatial relationships of the various fragments when compared with axial scan, 3D-CT images provided better understanding of the relationships of the displaced columns and the position of the stable fragment (iliac fragment which is attached to the sacroiliac).⁽¹⁵⁾

Magnetic resonance imaging

Some studies have shown the superiority of MRI under particular circumstances such as the detection of intra-articular splinters, appreciation of the femoral head, and detection of hidden fractures mainly in the elderly however, its use remains minor with pelvic trauma in their acute phase⁽⁵¹⁾

MRI has revolutionized the investigation of bone, joint and soft tissue abnormalities. Multi-planar imaging capability and high contrast resolution mean that the presence and extent of pathology can be defined far more accurately.⁽⁵²⁾

MRI demonstrates abnormal bone marrow changes and provides a cross sectional view of soft tissue anatomy⁽⁵³⁾, Magnetic resonance imaging is a very sensitive method for detecting insufficiency fractures; demonstrating characteristic bone marrow oedema and frequently also fracture lines MRI can be helpful in distinguishing insufficiency from pathologic fractures due to tumour infiltration.⁽⁵⁴⁾

The ligaments are not appreciated on plain films and to some degree with the CT scan. But MRI is very useful for evaluating these ligaments when the pelvis is severely fractured.⁽⁵⁵⁾

AIM OF THE WORK

The aim of this work will be directed to study the role of Multi-Detector Computed Tomography (MDCT) over Conventional Radiography in evaluation and clearing the diagnosis of osseous injuries of the pelvis.

PATIENTS

The present prospective study included 30 patients known or clinically suspected pelvic fracture referred to the radio-diagnosis department at Alexandria University Hospital.

METHODS

All the studied patients were subjected to the following:

- I. Full history taking about type of trauma.
- II. Thorough clinical examination.
- III. Plain X-ray of the pelvis:
 1. AP view.
 2. Inlet / Outlet views whenever possible.
- IV. Non enhanced MDCT of the pelvis:
 1. Multi-Planar volume Reformation (MPR).
 2. Three-dimensional Volume Rendering (VR).
- V. The medical ethics were considered: the patient should be aware of the examination, patient agreement is obtained, the economic status of the patient is considered and the patient has to get benefit from the examination.

HRCT technique on MDCT scanner

Thin axial section images (1 mm slice thickness) with a sharp reconstruction algorithm. On multi-detector CT (MDCT) scanner (Philips MX16, Philips Healthcare), high-resolution CT data sets were acquired lying supine, arms comfortably on the chest or above the head and lower legs supported. The scan started above the iliac crests to include all of fifth lumbar vertebra. The inferior landmarks were to entirely include the ischial tuberosities and inferior pubic rami, and through the lesser trochanters of the femurs.

Scan parameters

Scanning parameters were:

- Volumetric sharp kernel algorithm.
- Increments on both sharp kernel (B70) and very smooth (B10)
- Slice thickness: 1 mm.
- Rotation time: 0.5 second.
- Detector Collimation: 1 mm.
- KVp and mA per slice: 140 KVp and approximately 145 mA.

Reconstruction methods

The acquired images were sent to highly specialized workstations. The highly influential tools available at these workstations were mandatory in evaluating and diagnosing the encountered diseases. Volume Rendering and Multi-Planar Reconstruction of the acquired thin sliced axial images facilitated not only coronal and sagittal viewing but also 360 degrees.

RESULTS

This study included 30 patients with pelvic fractures. They were 21 males (70%) and 9 females (30%) with male to female ratio of 2.3:1. Their ages ranged between 13 and 85 years with a mean age of 36 years (Table 1).

Table 1: Distribution of patients according to age and sex (n=30).

Age in years	Males (%)		Females (%)		Total	
	n	%	n	%	n	%
10 > 20	3	10	--	--	3	10
20 > 30	11	36.67	2	6.66	13	43.34
30 > 40	3	10	1	3.33	4	13.33
40 > 50	--	--	2	6.66	2	6.66
50 > 60	3	10	1	3.34	4	13.33
60 > 70	--	--	1	3.34	1	3.34
70 > 80	1	3.33	1	3.34	2	6.66
80 > 90	--	--	1	3.34	1	3.34
Total	21	70	9	30	30	100

The most common cause was RTA (road traffic accidents) in 20 patients (66.66%), Blunt trauma in 7 patients (23.34%) and fall from height in 3 patients (10%). (Table 2)

Table 2: Distribution of patients according to cause of trauma (n=30).

Couse of trauma	Number of patients	%
RTA	20	66.66
Blunt Trauma	7	23.34
Fall from Height	3	10

The fractures were stable fracture in 18 patients (60%) is more common than unstable in 12 patients (40%). (Table 3)

Table 3: Distribution of all patients according to final diagnosis by CT (n=30).

Stability	Number of patients	%
Stable	18	60
Unstable	12	40

The fractured innominate bones and side of fracture where pubic bone is the most bone fractured in 22 patients 73.34% (23, 34% in Right side, 20% in the Left and 20% bilateral), The Ilium where fractured in 18 patients 60% (36.66% in right side and 23.34% in the Left side), followed by the ischium in 3 patients 10% (6.66% in Left side and 3.34% in Bilateral) (Table 4).

Table 4: Distribution of patients according to side of fracture (n=30).

Side of fracture	Pubis (%)		Ilium (%)		Ischium %	
	n	%	n	%	n	%
Right	7	23.34	11	36.66	--	--
Left	6	20	7	23.34	2	6.66
Bilateral	9	30	--	--	1	3.34
Total	22	73.34	18	60	03	10

The suspected fractured in plain radiography and confirmed by MDCT was in 10 patients 33.3% (2 in Ilium, 3 in Ischium, 1 in pubis, 4 in sacrum), and the missed fractured in plain radiography and diagnosed in MDCT was in 6 patients 10% (2 in Ischium, 1 in Pubis, 3 in Sacrum). (Table 5)

Table 5: Distribution of patients with suspected and missed fracture in plain radiography and diagnosed by MDCT (n=30).

Bone	Suspected fracture	Missed fracture
Ilium	2	-
Ischium	3	2
Pubis	1	1
Sacrum	4	3
Total	10	6

The Type of pelvic fractures in our study according to Young-Burgess Classification which is a mechanistic classification system that classified the fracture according to direction of force : lateral compression (LC), anteroposterior compression (APC), vertical shear (VS) and combined mechanical injury(CMI) , and the statistics were as following: Lateral compression (LC) in 19 patients 63.34% (LC1 13.34% , LC2 30% , LC3 20%) , anteroposterior (APC) in 7 patients 23.34% (APC1 13.34% ,APC2 6.67%, APC3 3.34%) ,vertical shear (VS) in 2 patients (6.66%) and combined mechanical(CMI) in 2 patients (6.66%). (Table 6)

Table 6: Distribution of patients according to young-burgess classification (n=30).

Type	Subtype	n	%	n	%
Anteroposterior Compression	I	4	13.34	7	23.34
	II	2	6.67		
	III	1	3.34		
Lateral Compression	I	4	13.34	19	63.34
	II	9	30		
	III	6	20		
Vertical shear				2	6.66
Combined Mechanical Injury				2	6.66

Type of pelvic fractures in our study according to Tile Classification where the pelvis is divided into the posterior arch (posterior to the acetabulum) and the anterior arch (anterior to the acetabulum), Fracture type is dictated by the stability of the posterior arch (sacroiliac complex), with a spectrum ranging from stable type A injuries to unstable type C fractures, , the statistics were as following: Type A2 in 12 patients (40%), Type B1 in 5 patients (16.66%), Type B2 in 9 patients (30%), Type B3 in 2 patients (6.67%) and Type C1 in 2 patients (6.67%). (Table 7)

Table 7: Distribution of the patients according to tile classification (n=30).

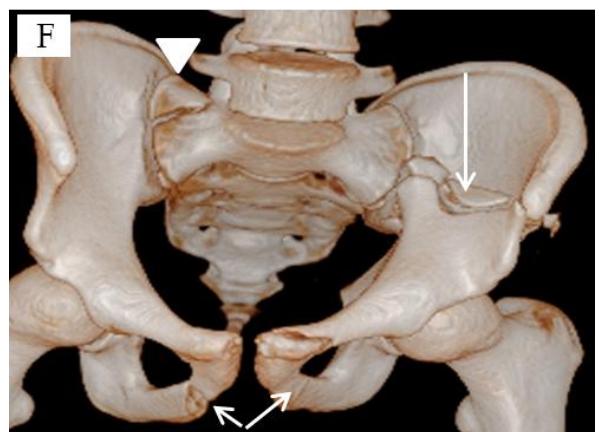
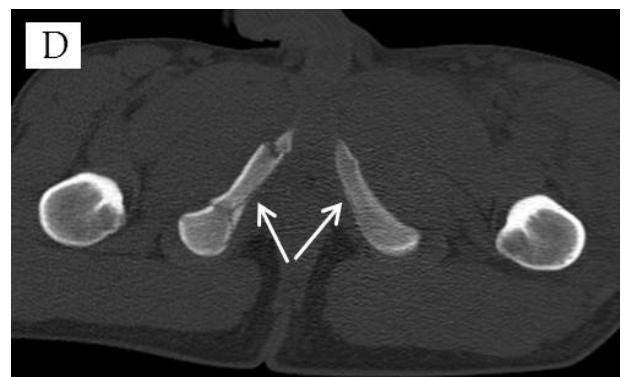
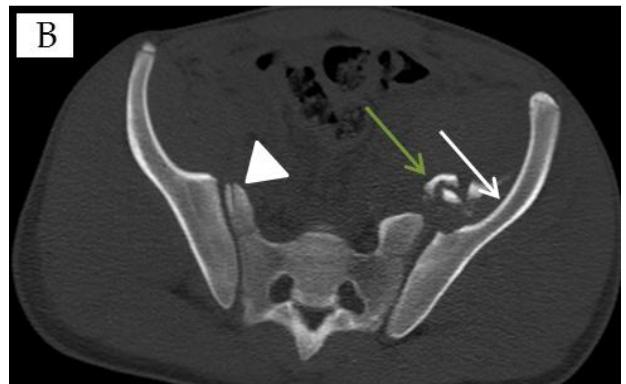
Type of Fracture	Number of patients	%
A1	--	--
A2	12	40
B1	5	16.66
B2	9	30
B3	2	6.67
C1	2	6.67
C2	--	--
C3	--	--

The percentage of comminuted fracture in the patients where comminuted fractured in 24 patients (80%) and non-comminuted fractures in 6 patients (20%). (Table 8)

Table 8: Distribution of the patients according to commination existence (n=30).

Comminuted OR Not	Number of patients	%
Comminuted	24	80
Non Comminuted	6	20

Case (1)



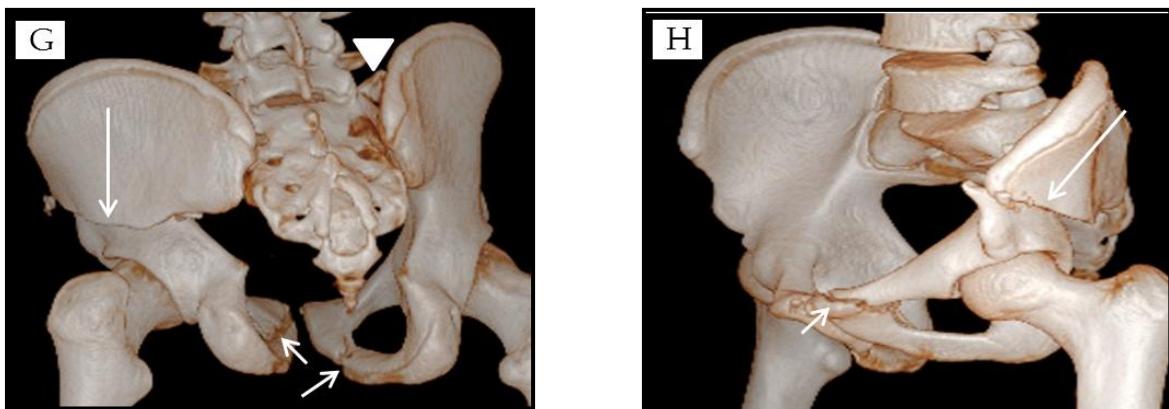
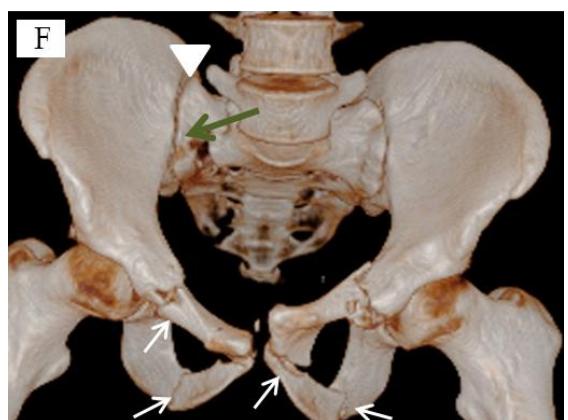
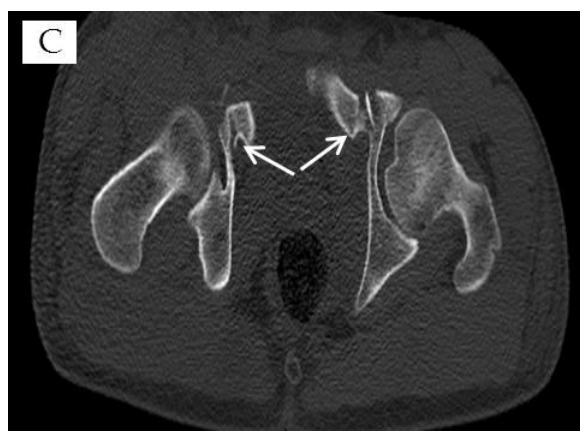
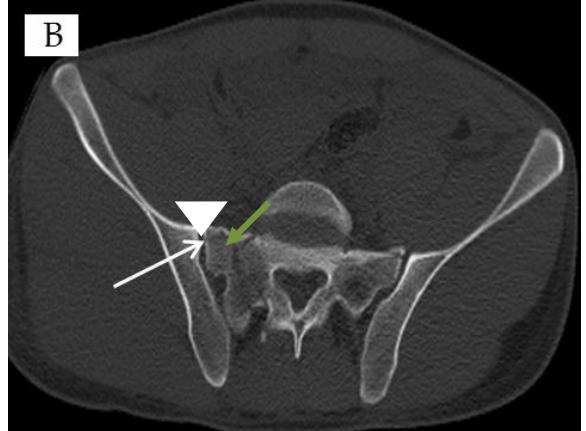
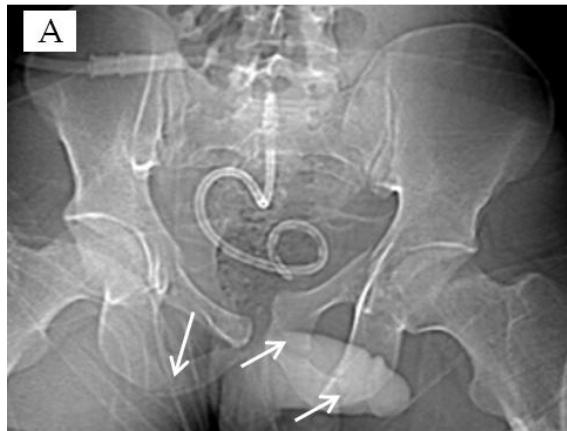


Fig. (30): 16 years old male with history of Falling from height, (A) plain x ray anteroposterior view, (B, C, D) axial, (E) coronal CT bone windows and (F,G,H) VR images they are showing left iliac wing bone fracture reach the SI joint (long arrows in B,F,G,H) with diastasis anterior of the left SI joint, and sacral fracture (arrow head in B,E,F). Fragment is noted in B and E (Green arrow). There is fracture in both right and left inferior pubic rami (short arrows in C,D,F,G,H).

Conclusion: Lateral compression pelvic fracture (Young classification), Type B2 (Tile classification).

Case (2)



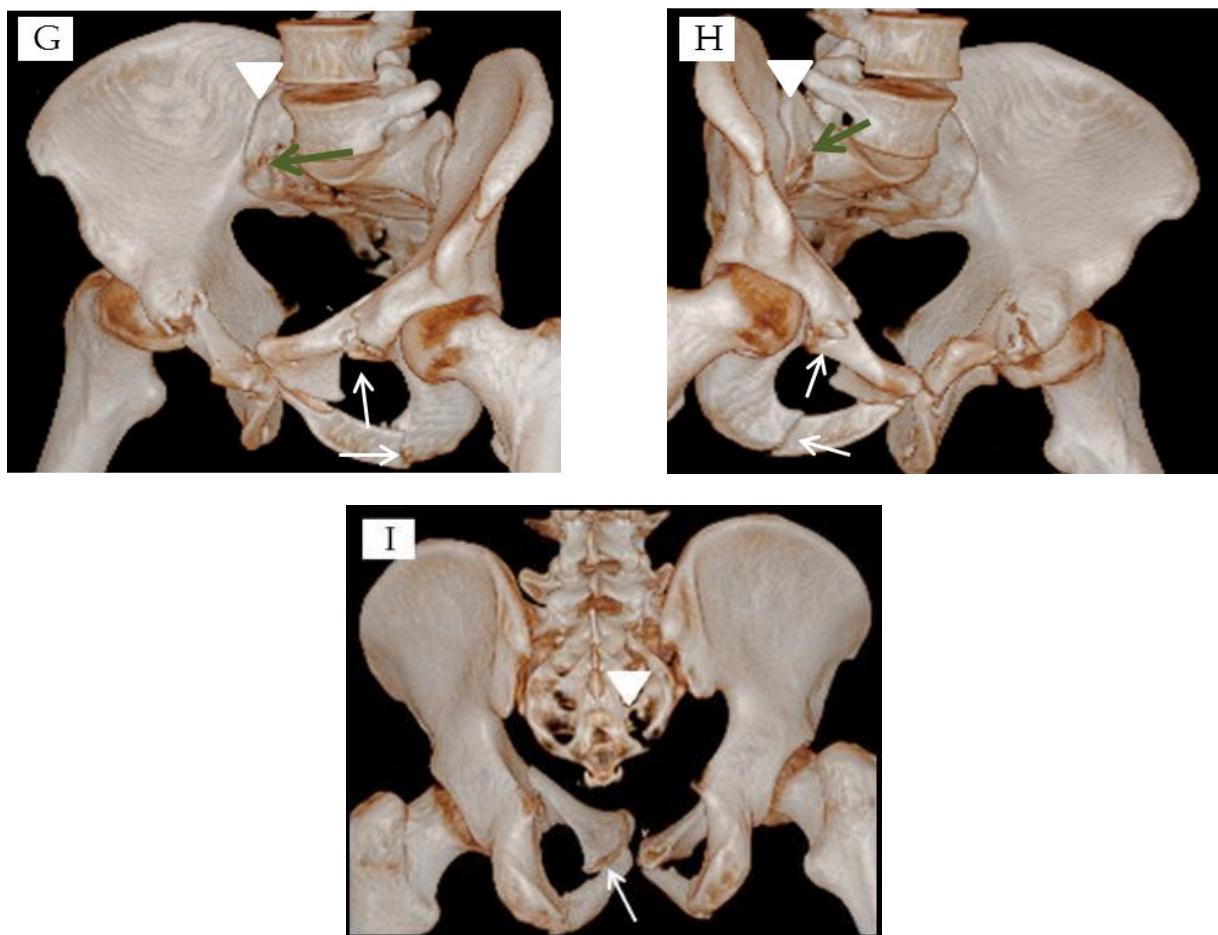
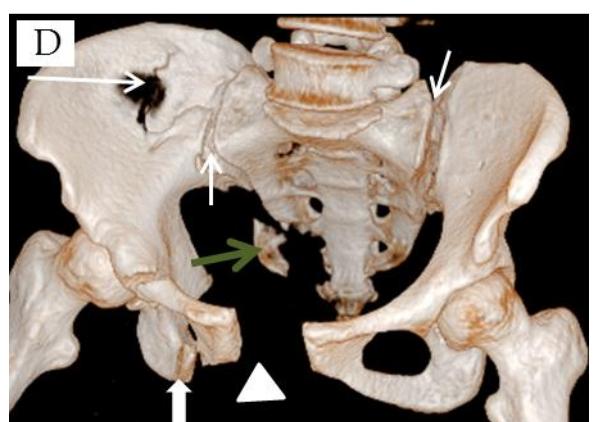
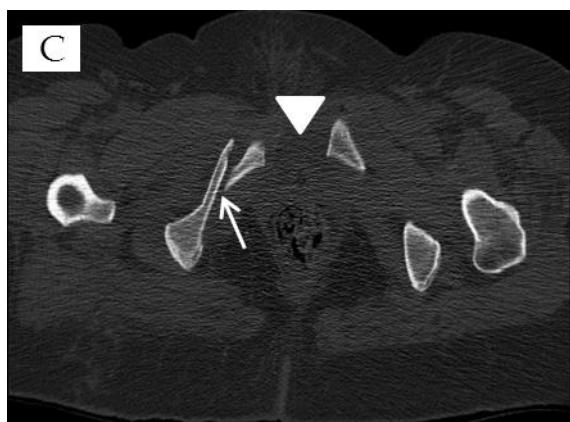
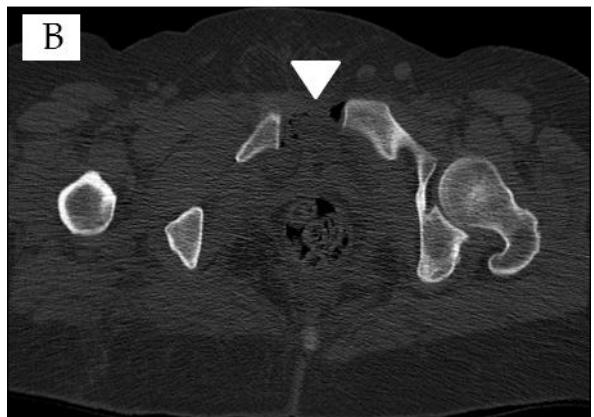
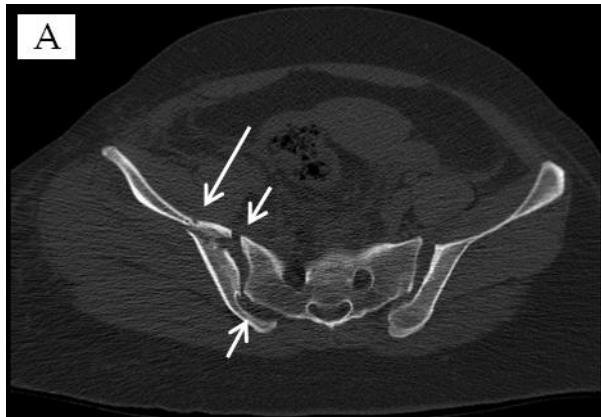


Fig. (31): 23 years old male with history of road traffic accident, (A) plain x ray anteriorpostero view, (B, C, D) axial CT, (E) coronal CT bone windows and (F,G,H, I) VR images they are showing right anterior SI joint diastasis (long arrow in B) with sacral fracture (arrow heads in A,B,E,F,G,H,I) . Both right and left superior and inferior pubic rami are fractured (short arrows in A,C,D,F,G,H,I) , with fragment (Green arrow in B,E,F,G,H).
Conclusion: lateral compression pelvic fracture (Young classification), Type C1 (Tile classification).

Case (3)



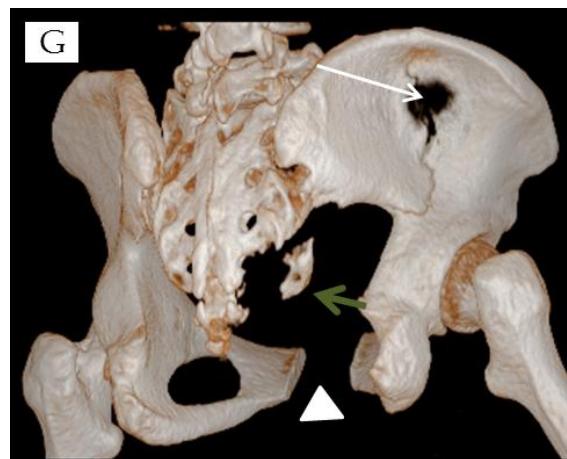
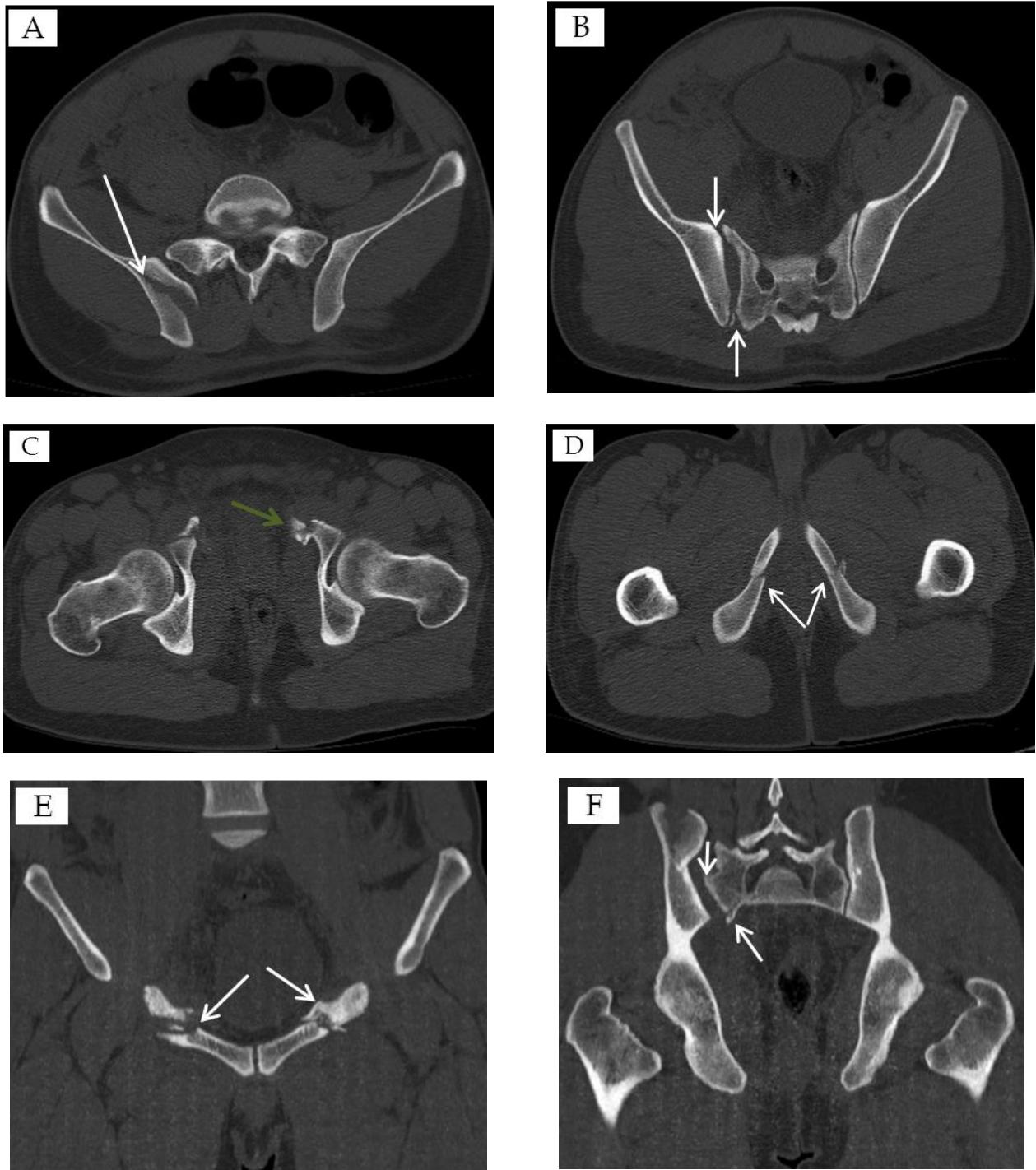


Fig. (32): 35 years old female with history of road traffic accident, axial bone window CT in (A,B,C) and VR in (D,E,F,G) show widening of the symphysis pubis (arrow head in B,C,D), right iliac wing fracture (long arrow in A,) reach to right SI joint that showed diastasis (small arrow in A,D). There is fracture in both inferior and superior right pubic rami (arrow in C and thick arrow in D,E,F). Fragment is seen in D (Green arrow).

Conclusion: anteroposterior compression pelvic fracture (Young classification), Type B3 (Tile classification).

Case (4)



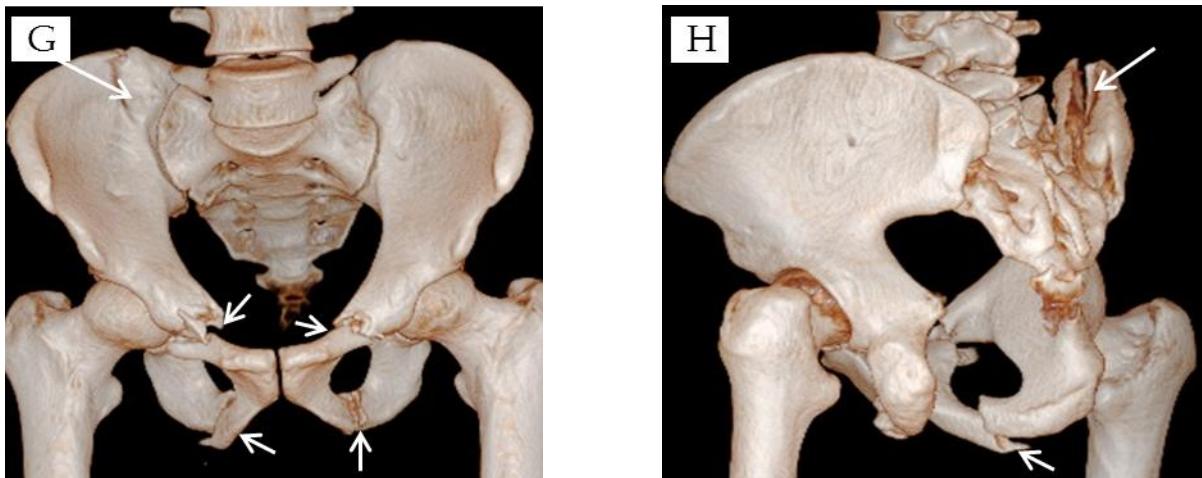


Fig. (33): 23 years old male with history of road traffic accident, (A, B, C, D) axial CT, (E, F) coronal CT bone windows and (G,H) VR images (anterior view in H and posterior oblique view in H) they are showing right iliac bone fracture reaches to the right SI joint (long arrow in A,G,H) ,the right SI joint diastasis in both anterior and posterior with (short arrows in B). Both right and left superior and inferior pubic rami are fractured (short arrows in D, E,G,H) , with fragment (Green arrow in C).

Conclusion: lateral compression pelvic fracture (Young classification), Type C1 (Tile classification).

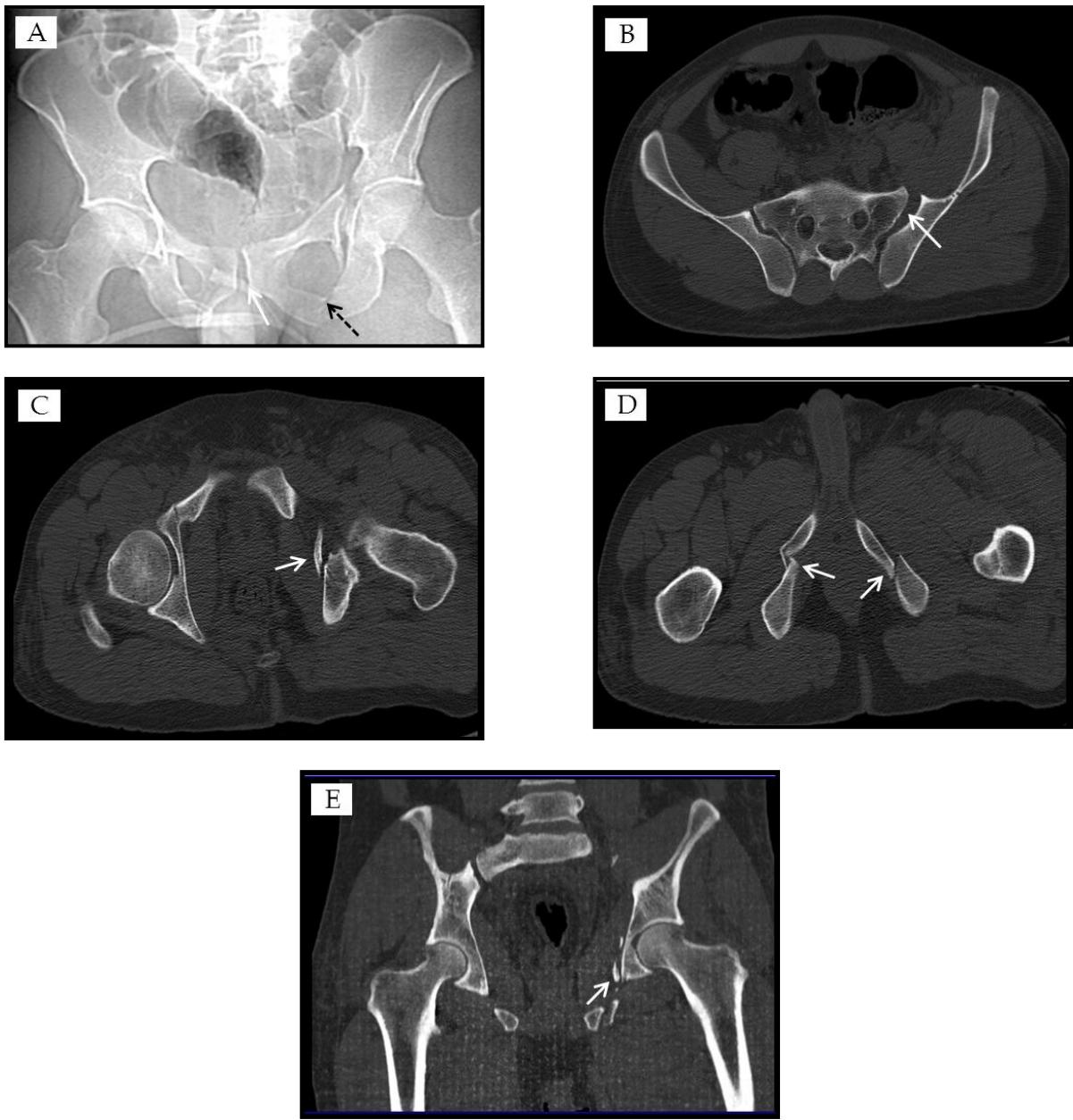
Case (5)

Fig. (34): 30 years old male with history of falling from height, plain x-ray anteriorposterior view in (A) show pubic symphysis diastasis (short white arrow), and a fracture of the left inferior pubic rami (black arrow), (B,C,D) Axial bone window CT of the pelvis showing left sacroiliac diastasis which didn't seen in plain radiography in (B) and both inferior pubic rami in (C,D) , (E) Coronal CT of the pelvis show the fragments.

Conclusion: Vertical shear pelvic fracture (Young classification), Type B2 (Tile classification)

DISCUSSION

Pelvic fracture accounts for 1-3 % of all skeletal fractures.⁽⁵⁶⁾ Most pelvic fractures results from motor vehicle accidents, but severe complex pelvic fractures may also result from falls from buildings.⁽⁵⁷⁾

The routine radiographic assessment of the pelvis always begins with a standard anteroposterior (AP) view and can be augmented with a variety of oblique views. Inlet and outlet views, obtained by angling the tube caudally and cranially respectively, can help in visualizing the obturator rings and assessing the integrity of the pelvic ring. CT is a more precise method of evaluating the acutely injured pelvis, allowing detection and characterization of subtle fractures and fragments in areas of complex anatomy. In addition, it provides detailed information about the soft tissues in and around the pelvis, such as hematomas. With post-processing techniques, three-dimensional reconstructions of the traumatized pelvis can be created and manipulated to provide the orthopedic surgeon with information useful in planning treatment.⁽⁵⁸⁾

Although pelvic x-ray is a routine part of the primary survey of poly traumatized patients according to advanced trauma life support guidelines, it cannot provide soft tissue injuries .So pelvic CT scan is the gold standard imaging technique in the diagnosis of pelvic fractures.⁽⁵⁹⁾

The higher spatial resolution permits acquisition of sub millimeter near-isotropic voxels that can be reformatted in any plane with spatial resolution equivalent to that of axial images.⁽⁶⁰⁾ Multi-planar reformatted (MPR) images in the standard sagittal and coronal planes are readily generated with no additional time or labor required on the part of the radiologist. In certain circumstances, additional oblique or curved planar MPR images may also be generated.⁽⁶¹⁾

All these are achieved following a single data acquisition without the need for gantry angulation.⁽⁶²⁾

For years the role of CT has been re-evaluated because of the technological advance of spiral CT and, moreover, the recently introduced multi-detector scanners that make study scan times 2–5 times faster.⁽⁶³⁾

The advent of multi-detector-row technology combined with sub second rotation and sub millimeter collimation resolved the long-lasting trade-off between scan volume and slice thickness, now allowing for an acquisition of large scan volumes in very small slice thicknesses.⁽⁶⁴⁾ The combination of high in-plane and z-resolution provides near isotropic image reconstruction, thus rendering possible high quality multi-planar image reformation in each spatial orientation⁽⁶⁴⁾. This is particularly useful in patients admitted after severe trauma, where one whole body scan in principle suffices to screen for both soft tissue damage and injuries of the pelvis.⁽⁶⁵⁾ Such an approach would not only significantly reduce the duration of the diagnostic procedure,⁽⁶⁶⁾ but also save costs, minimize radiation dose and avoid harmful patient manipulation.⁽⁶⁷⁾

High-quality multi-planar reformation (MPR) and three-dimensional (3-D) images can be created at the workstation using the volumetric data. The MPR images give excellent structural detail, and the 3-D images help in understanding the spatial relations, which is important for fracture classification and for preoperative planning. Pelvic and acetabular trauma is where 3-D imaging first made a significant clinical impact, and it is

now a standard requisite for surgical planning, being a valuable complement to axial and MPR images.⁽⁶⁸⁾

The present prospective work included 30 patients with pelvic fracture. All the patients were examined by MDCT. They were 21 males (70%) and 9 females (30%) with male to female ratio of 2.3:1. Their ages ranged between 13 and 85 years with a mean age of 36 years.

Wade Smith et al ⁽⁶⁹⁾ state that the causes of pelvic fracture composed as follows road traffic accidents (RTA) 78% , Fall from Height 10% and Blunt trauma 12%.

While **Shelly Gurevitz et al** ⁽⁷⁰⁾ state that traffic accidents (RTA) 59% , Fall From Height 17% and blunt trauma 24%.

And **Christopher J. Dente** ⁽⁷¹⁾ state that traffic accidents (RTA) 72% , Fall From Height 7% and blunt trauma 21%.

In our study the RTA (road traffic accidents) in 20 patients (66.67%), Fall from Height in 3 patients (10%), and Blunt trauma in 7 patients (23.34%).

Scott F. Gylling et al ⁽⁷²⁾ state in his study that the stable fractured is 61% and the unstable fractured 39%,**C. Herzog et al** ⁽⁷³⁾ state that the ratio of stable fractures I s 39.5% and the unstable fracture is 60.5%.

While **A. Glnsslen et al** ⁽⁷⁴⁾ state that the stable percentage is 54.8% and the unstapled fractured is 45.2 %.

In this study the stable fracture were counted with 18 patients (60%) were it is more common than unstable with 12 (40%).

In the present study the fractured innominate bones and side of fracture where pubic bone is the most bone fractured in 22 patients 73.34% (23.34% in Right side, 20% in the Left and 20% bilateral), The Ilium where fractured in 18 patients 60% (36.67% in right side and 23.34% in the Left side), followed by the ischium in 3 patients 10% (6.67% in Left side and 3.34% in Bilateral). While **Tian-wu Chen et al** ⁽⁷⁵⁾ state that pubic fractured 80.84% (20.96% in the right side , 22.16 in the left side, 37.72% bilateral), Ilium 23.96% (6.50% in right side, 7.19% in left side , 10.18% bilateral) and ischium fractures 6% (1.8% right , 1.8% left , 2.4% bilateral).

Li FP et al ⁽⁷⁶⁾ state in his study that the sensitivity of plain radiography to detect pelvic fractures was 79% where the suspected fractured in plain radiography and confirmed by MDCT were in 21% of the patients and the missed fractured in plain radiography and diagnosed in MDCT were in 14% of the patients,while **Wedegartner U et al** ⁽⁷⁷⁾ state that the was sensitivity 83% where the suspected were in 26% and the missed fractured were in 17%, and **Li M et al** ⁽⁷⁸⁾ state that the sensitivity were in 86.7 % with 20% suspected fractured and 13.3% missed fractures, while **Chmelova J et al** ⁽⁷⁹⁾ state that the sensitivity was 74% with 26% missed fractured.

In this study The suspected fractured in plain radiography and confirmed by MDCT were in 10 patients 33.3% (2 in Ilium, 3 in Ischium, 1 in pubis, 4 in sacrum), and the missed fractured in plain radiography and diagnosed in MDCT were in 6 patients 10% (2 in Ischium, 1 in Pubis, 3 in Sacrum).

Ganslen A et al ⁽⁷⁴⁾ stated that the soft tissues and internal organs injured were as following the bladder and urethra 62.9%. In 23.1% the large pelvic vessels were injured, in 20.2% there was damage to the pelvic intestine and in 18.1% damage to the pelvic soft tissues. while in **McCormack R et al** ⁽³⁸⁾ study the injury to the bladder and urethra in 63%, 35% had associated head injuries and 20% had intestinal injuries.

In this study the soft tissues and internal organs injured were as following the bladder and urethra 62%, in 20% there was damage to the pelvic intestine and in 25% damage to the pelvic soft tissues.

The **Tile and Young-Burgess** classification systems are the most widely used today. Tile emphasized the concepts of stability and mechanism of injury in this system. Type A injuries are considered stable and may or may not involve the pelvic ring. Type B injuries are rotationally unstable but vertically stable; these include open book (AP compression) and lateral compression injuries. Type C injuries are rotationally and vertically unstable; these injuries may be unilateral or bilateral.

Young expanded **Tile's** classification and created a classification system to predict the mechanism of injury, which patients are more likely to be hemodynamically unstable, and what associated injuries the patient may have sustained. The Young-Burgess classification system divides pelvic ring disruptions into 4 major types: anterior-posterior compression, lateral compression, vertical shear, and combined mechanism injury. Based on radiographic appearance, the authors further subdivided anterior-posterior compression injuries into anterior-posterior compression I, II, and III and lateral compression injuries into lateral compression I, II, and III⁽²⁸⁾ the third group consisted of the vertical shear injury pattern, and the fourth group was made up of those injuries with combined mechanisms.⁽⁸⁰⁾

Theodore Manson, et al ⁽⁸¹⁾ state that the type of the pelvic fracture according to Young-Burgess Classification whereas the following lateral compression (LC) 77.2% (LC1 62.7 %, LC2 8.6 %, LC3 5.9 %), anteroposterior compression (APC) 18.3% (APC1 2.5 %, APC2 11.4 %, APC3 4.4 %), vertical shear (VS) 1.4 % and combined mechanical injury (CMI) 3 %.

While **A. Ganslen et al** state that anteroposterior compression (APC) 37.7% and lateral compression (LC) 41.1%., vertical shear (VS) 16.9% and combined mechanical injury (CMI) 4.3%.⁽⁷⁴⁾

While **Andrew J. Furey et al** ⁽⁸²⁾ Lateral compression (LC) 59.11% (LC1 34.17%, LC2 16.63%, LC3 8.31%), anteroposterior (APC) 33.26% (APC1 7.87%, APC2 18.65%, APC3 6.75%), vertical shear (VS) 2.02% and combined mechanical (CMI) 5.61%.

While **Christopher J. Dente et al** ⁽⁸³⁾ study state that the Lateral compression (LC) is 52% (LC1 18% , LC2 18% , LC3 16%) , anteroposterior (APC) 43% (APC1 5% ,APC2 18%, APC3 20%) ,vertical shear (VS) 5%.

In our study lateral compression (LC), anteroposterior compression (APC), vertical shear (VS) and combined mechanical injury(CMI) , and the statistics were as following: Lateral compression (LC) in 19 patients 63.36% (LC1 13.34% , LC2 30% , LC3 20%) , anteroposterior (APC) in 7 patients 23.34% (APC1 13.34% ,APC2 6.67%, APC3 3.34%) ,vertical shear (VS) in 2 patients (6.67%) and combined mechanical(CMI) in 2 patients (6.67%).

Tian-wu Chen et al ⁽⁸⁴⁾ state that the type of pelvic fractures according to Tile classification and the statistics were as following: A 18.56% (Type A1 11.38% and Type A2 7.19%), Type B 43.11% (Type B1 10.78%, Type B2 15.58% and Type B3 16.77%), and Type C 38.32%, (Type C1 2.4%, Type C2 11.98% and Type C3 23.95%).

While **A. Gänsslen et al** ⁽⁷⁴⁾ in his study state that (54.8% type A), (24.7% type B injury), and (20.5% type C).

While **Andrew J. Furey et al** ⁽⁸²⁾ state in his study that (27.64% type A), (53.94% type B injury), (and 18.43% type C).

In our study the classification is composed as following: Type A were in 12 patients 40% (A2 in all 12 patients), Type B in 16 patients 53.43% (B1 in 5 patients 16.67%, B2 in 9 patients 30%, B3 in 2 patients 6.67%) and Type C were in 2 patients 6.66% (C1 in the 2 patients).

Gill K et al ⁽⁴⁸⁾ mention in his study that the pelvic fracture was treated non-operatively in (48%) of patients, by external fixation alone in (21%), by primary open reduction and internal fixation in (20%), by combined external and internal fixation in (5%) and by initial external fixation with subsequent conversion to internal fixation in 13 (7%), while **Gabbe BJ et al** ⁽⁸⁵⁾ state that lmost half (47%) were managed through internal fixation, (21%) were using an external fixation, while (27%) received both internal and external fixation.

Kelly A.et al ⁽⁸⁶⁾ state in his study that (51%) comminuted fractures and 49% non-commminuted fractured, While in our study the percentage of comminuted fracture in the patients where the comminuted fractured was in 24 patients (80%) and non-commminuted fractures in 6 patients (20%).

SUMMARY

This prospective study included 30 patients known or clinically suspected pelvic fracture referred from Emergency Room and Orthopedic Department of Alexandria Teaching University Hospital to Radiology Department. All the patients were examined by CT evaluation. They were 21 males (70%) and 9 females (30%) with male to female ratio of 2.3:1. Their ages ranged between 13 and 85 years with a mean age of 36 years.

The aim of this work was directed to study the role of Multi-Detector Computed Tomography (MDCT) over Conventional Radiography in evaluation and clearing the diagnosis of osseous injuries of the pelvis.

In the present prospective study, all patients were subjected to the complete history taking, thorough clinical examination, pelvic X-rays (AP, inlet/outlet, Oblique “external / internal” views whenever possible.) and none enhanced MDCT of the pelvis (Multi-planar volume reformation MPR, Three-dimensional VR.).

The examinations were done on Philips MX 16, Philips Healthcare. With volumetric sharp kernel algorithm. The scan parameters 140 kVp and approximately 145 mA per slice, tube rotation 0.5s and slice thickness 1 mm.

Pelvic fracture is a serious injury that is associated with significant morbidity and mortality. This is a result of the high energy transfer to the pelvic region. Fractures of the pelvic ring have been reported to comprise 2% to 8% of all skeletal injuries. Patients are most often young males in their early 30s, and motor vehicle collisions are the most common inciting cause. Because of the high energy involved, patients with pelvic ring disruptions usually have multiple injuries. Morbidity and mortality is also high, with overall mortality rates of 17% for patients with pelvic fractures.

Digital radiography and Computed Tomography are valuable for evaluating pelvic fractures. In most poly trauma patients, the first imaging study today is MDCT. Although axial CT images have a higher diagnostic accuracy in detecting and characterizing pelvic injuries than radiography, evaluation with MPR images has been shown to increase diagnostic accuracy. Pelvic trauma is where 3-D imaging first made a significant clinical impact, and it is now a standard requisite for surgical planning, being a valuable complement to axial and MPR images.

Patients were found according to young classification Lateral compression (LC) in 19 patients (63.36%) anteroposterior (APC) in 7 patients (23.34%), vertical shear (VS) in 2 patients (6.67%) and combined mechanical(CMI) in 2 patients (6.67%)and according to tile classification Type A2 patients in 12 patients (40%), Type B1 in 5 patients (16.67%), B2 in 9 patients (30%), B3 in 2 patients (6.67%), and Type C1 in 2 patients (6.67%).

Multi slice CT considered the modality of choice in evaluation of pelvic fractures and its classification.

CONCLUSIONS

- Digital radiography and Computed Tomography are valuable for evaluating pelvic fractures.
- MDCT is the first imaging study today in most poly traumatic patients.
- MDCT decrease the uncomfortable positions in order to obtain diagnostic images. This is high value in patients who are already in pain.
- MDCT Multi-planar (MPR) and the 3-D capabilities improving, detection, characterization, staging of pelvic fractures and the pre-surgical planning.
- MDCT provides detailed information about the soft tissues in and around the pelvis.
- MDCT very important component in the pre-operative assessment of pelvic fractures.
- MDCT is the most suitable technique for assessment of fractures of pelvic and their classification.
- MDCT is more sensitive than plain radiography in detection and diagnosis of the pelvic fractures and can change the stability diagnosis of the fractures.

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**ROLE OF MULTI-DETECTOR COMPUTED TOMOGRAPHY
IN EVALUATION OF PELVIC FRACTURES**

دور الأشعة المقطعيية متعددة المقاطع في تقييم كسور الحوض

Protocol of a thesis submitted
to the Faculty of Medicine
University of Alexandria
In partial fulfillment of the
requirements of the degree of
**Master of Radiodiagnosis and
Intervention**

خطة بحث مقدمة
لكلية الطب
جامعة الإسكندرية
إيفاءً جزئياً
لشروط الحصول على درجة
الماجستير في الأشعة التشخيصية
والتدخلية

by من

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2012

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For his experience in MDCT Imaging

وذلك لخبرته في فحوصات

الأشعة المقطعيّة متعددة المقاطع



3.

ASSISTANT-RESEARCHER**الباحث المساعد****Ammar Ali Alani**

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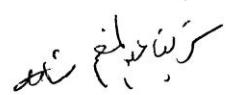
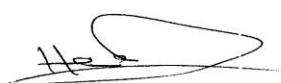
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INTRODUCTION

The pelvis is a complex bony ring comprised of multiple components. The sacrum and ilia make up the posterior portion of the ring, with the ischia and pubic bones anteriorly providing a connection between the lower limbs and trunk. However, the bony articulations, sacroiliac and pubic symphysis, are not inherently stable.⁽¹⁾

Pelvic fracture is a serious injury that is associated with significant morbidity and mortality. This is a result of the high energy transfer to the pelvic region. Road traffic accidents and falls from height are by far the most common mechanisms of injury.⁽²⁾

Fractures of the pelvic ring have been reported to comprise 2% to 8% of all skeletal injuries.⁽³⁻⁵⁾ Patients are most often young males in their early 30s, and motor vehicle collisions are the most common inciting cause.^(6,7) Because of the high energy involved, patients with pelvic ring disruptions usually have multiple injuries.⁽⁶⁾ Morbidity and mortality is also high, with overall mortality rates of 17% for patients with pelvic fractures.⁽⁷⁾

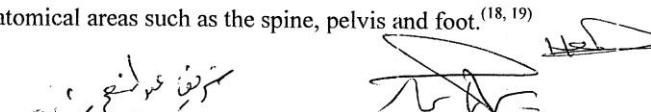
Pelvic fractures were classified according to pelvic instability; if a pelvic fracture is stable, it is Type A; a fracture that is unstable to rotation but vertically stable is termed Type B; severe pelvic ring disruption that is unstable to both rotation and vertical displacement is Type C.⁽⁸⁾

Detection and assessment of pelvic fractures is a critical component of the initial evaluation of any major trauma patient.⁽⁹⁾ Pelvic fractures are frequently complex and the precise pathological anatomy is not easily demonstrated by routine radiographs.⁽¹⁰⁾ Plain radiographs alone have limited sensitivity for detection of pelvic fractures compared with CT.⁽¹¹⁾ Fractures of the sacrum and acetabulum are most easily overlooked.^(10, 11)

Digital radiography and Computed Tomography are valuable for evaluating pelvic fractures.⁽¹²⁾ In most polytrauma patients, the first imaging study today is MDCT. Although axial CT images have a higher diagnostic accuracy in detecting and characterizing pelvic injuries than radiography, evaluation with MPR images has been shown to increase diagnostic accuracy.⁽¹³⁾ Pelvic trauma is where 3-D imaging first made a significant clinical impact, and it is now a standard requisite for surgical planning, being a valuable complement to axial and MPR images.⁽¹⁴⁾

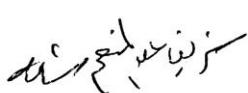
CT is useful for detecting intra-articular fragments, fragment interposition, marginal impaction, occult pelvic ring fractures and evaluating the sacroiliac complex to determine if vertical instability is present.^(15, 16)

MSCT detected additional fractures in 17% of patients not seen on conventional radiographs. In some patients, MSCT changed the fracture classification by delineating the full extent of the fracture. MPR visualize sacral fractures better than axial source images. MSCT of the pelvis is required for correct fracture detection.⁽¹⁷⁾ MSCT has increased the speed, efficiency and accuracy of computed tomographic imaging in musculoskeletal trauma. Added advantages such as MPRs and 3D imaging have greatly enhanced the ability to evaluate complex anatomical areas such as the spine, pelvis and foot.^(18, 19)



6.

MPR technique proved to be superior in the detection of fractures of the pelvis, leading to significantly better results than conventional radiographs and markedly better results than transverse slices alone.⁽²⁰⁾ In severe trauma patients MDCT proved to be far superior in the detection and classification of traumatic fractures of the spine and the pelvis. Particularly thin-slice technique combined with multiplanar reformation leads to significantly better results than conventional radiographs or transverse images alone.⁽²¹⁾



JW

7.

AIM OF THE WORK

The aim of this work will be directed to study the role of Multi-Detector Computed Tomography (MDCT) over Conventional Radiography in evaluation and clearing the diagnosis of osseous injuries of the pelvis.

Hes

✓✓✓

as always

X
8.

PATIENTS

A prospective study will be conducted on 30 patients presenting with pelvic trauma referred to the radi-diagnosis department at Alexandria university Hospitals.

Reed
as follows *✓*

METHODS

Selected patients will be subjected to:

- Full history taking.
- Thorough clinical examination.
- Plain X-ray of the pelvis:
 - AP view.
 - Oblique views (external , internal).
 - Inlet / Outlet views.
- Non enhanced MDCT of the pelvis:
 - Multi-planar volume reformation (MPR).
 - Three-dimensional VR.
- The medical ethics will be considered. The patient has to get benefit from the examination [An informed consent will taken from patient in case of incompetent patient the informed consent will be from the guardians].



Two handwritten signatures are present at the bottom of the page. The signature on the left appears to begin with 'H' and ends with '...'. The signature on the right appears to begin with 'S' and end with '...'. Below these signatures is a large, faint, handwritten mark that looks like a stylized 'W' or 'M'.

Ethics Of Research

Research on human or human products:

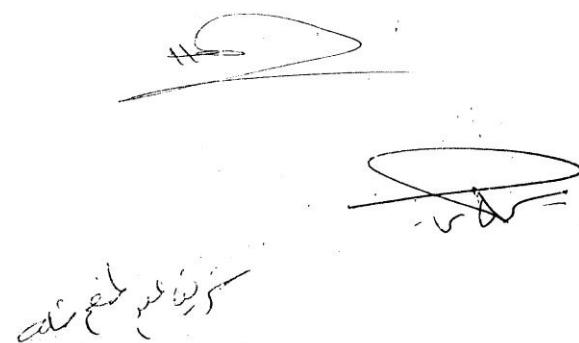
- Prospective study:** informed consent will taken from patient. In case of incompetent patient the informed consent will be from the guardians.
- Retrospective study:** Confidentiality of record will be considered.
- DNA/ genomic material:** informed consent for DNA/ genomic test and for research will be taken from patients. No further tests will be carried out except with further approval of committee and patients. If the samples will travel outside Egypt the researcher will be responsible for transportation and security approval.
- All drugs used in the research is approved by the Egyptian ministry of health.

Research on animal:

- The animal species is appropriate to the test.
- After test, if the animal will suffer it will be euthanized and properly disposed.
- After operation, it will have a proper postoperative care.

RESULTS

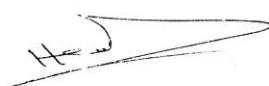
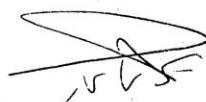
The results of this study will be calculated, tabulated and statistically analyzed according to the appropriate methods.



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DISCUSSION

The results will be discussed in view of achievement of the aim, their significance and their comparison with other available previous relates researches.

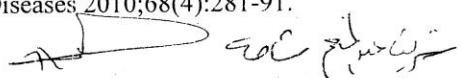
A handwritten signature consisting of a stylized 'H' or 'J' shape followed by a long, sweeping flourish.A handwritten signature consisting of a large, open 'S' shape with a diagonal line through it.A handwritten signature consisting of a stylized 'a' or 'z' shape with a vertical line extending downwards.

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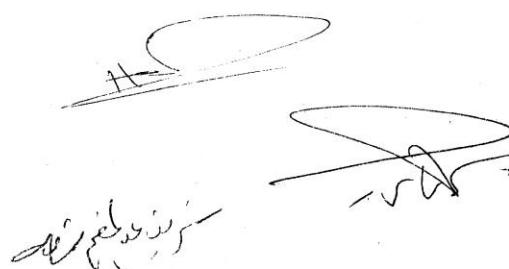
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A cluster of three handwritten signatures or initials, appearing to be "H.S.", "N.W.", and "D.J.".

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A photograph of three handwritten signatures. One signature is at the top left, another is at the top right, and a third is at the bottom center.

الملخص العربي

شملت هذه الدراسة ٣٠ مريضاً باشتباه سريري بكسير في الحوض والمحولين من قسم الأشعة التشخيصية في مستشفى جامعة الإسكندرية، حيث تم فحص جميع المرضى بواسطة الأشعة المقطعة. فكان العدد ٢١ من الذكور ٧٠٪ و ٩٪ من الإناث ٣٠٪ مع نسبة الذكور إلى الإناث من ١:٣. وترواحت أعمارهم بين ١٣ و ٨٥ عاماً مع متوسط عمر ٣٦ عاماً.

كان الهدف من هذا العمل هو دراسة دور التصوير المقطعي متعدد المقاطع على الأشعة التقليدية في التقييم وتأكيد تشخيص الإصابات في عظم الحوض.

في هذه الدراسة ، تمأخذ التاريخ الكامل والفحص السريري الدقيق للمرضى، تصوير الحوض بالأشعة السينية كلما امكن ذلك (امامي خلفي ، "مدخل / مخرج" ، مائل ، "داخلي / خارجي") وتصوير بالأشعة المقطعة متعدد المقاطع بدون صبغة للوحض (الفحص الثلاثي الأبعاد والصور ثلاثية الأبعاد).

وقد أجريت الفحوصات على ضوء سرعة جي اي رباعي المواسح وسيمنس سدادسي المواسح. كانت عوامل الفحص ١٤٠ كيلو فلت و ١٤٥ مللي أمبير لكل مقطع ودوران الأنبوية ٥٠ ثانية وسمك المقطع ١ مم.

كسير الحوض هو إصابة خطيرة ذو معدلات الاعتلال والوفيات كبيرة. هذا هو نتائج لنقل الطاقة العالية إلى منطقة الحوض. وقد تم الإبلاغ عن كسور في الحوض لتشمل ٢٪ إلى ٨٪ من جميع إصابات الهيكل العظمي. غالباً ما تكون الحالات من الشباب الذكور في العقد الثالث ، السبب الأكثر شيوعاً هو حادث السير . بسبب الطاقة الهائلة، المرضي الذين يعانون من اضطرابات في حلقة الحوض عادة ما يكونون ذو إصابات متعددة. معدل المرض والوفيات مرتفع أيضاً، مع معدلات الوفيات الإجمالية بنسبة ١٧٪ للمرضى الذين يعانون من كسور الحوض.

التصوير الشعاعي الرقمي والتصوير المقطعي ذات قيمة لتقييم كسور الحوض. في معظم مرضى متعددي الإصابة تعتبر الأشعة المقطعة متعددة المقاطع هي الخيار الأول في التصوير. بالإضافة إلى أن الصور المقطعة المحورية لديها أعلى دقة التشخيص في الكشف وتوصيف إصابات الحوض من التصوير الشعاعي، قد تبين ان زيادة التقييم ودقة التشخيص تأتي مع الصور في الأبعاد الثلاثة وثلاثية الأبعاد. في إصابات الحوض التصوير ثلاثي الأبعاد يعتبر ذو تأثير سريري كبير، وتعتبر الان المعيار الاول لخطف العمليات الجراحية.

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مقدمة من

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للحصول على درجة

الماجستير

في

الأشعة التشخيصية

موافقون

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دور الأشعة المقطعة متعددة المقاطع في تقييم كسور الحوض

رسالة علمية

مقدمة إلى كلية الطب - جامعة الإسكندرية
إسناداً للدراسات المقررة للحصول على درجة

الماجستير

في

الأشعة التشخيصية

مقدمة من

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